BASELINE ASSESSMENT REPORT HYDROPOWER

Strategic Environmental Assessment of the Hydropower Sector in Myanmar

IN PARTNERSHIP WITH:

Australian Aid

MOEE

MONREC

IFC International Finance Corporation WORLD BANK GROUP

Creating Markets, Creating Opportunities

2121 Pennsylvania Avenue, N.W.
Washington, D.C. 20433
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ABBREVIATIONS

ADB	Asian Development Bank
AWC	Asia World Company, Myanmar
BAU	Business as usual
BOT	Build, operate and transfer
CDM	Clean development mechanism
CDOI	China Datang Overseas Investment Co. Ltd.
CFRD	concrete-faced rock-fill dam
Chaung	means river
CHEC	China Harbour Engineering Company
CPI	China Power Investment Corporation
CPIYN	China Power Investment Corporation - Yunnan Subsidiary
CSC	Chinese Consortium China
CSG	China Southern Grid
CTG	China Three Gorges Corporation
d/s	Downstream
E/S	Environmental and social
ECC	Environmental Compliance Certificate
EDF	Electricité du France
EGATi	Electricity Generating Authority of Thailand International
EIA	Environmental impact assessment
EMP	Environmental Management Plan
ESIA	Environmental and social impact assessment
F-JV/BOT	Foreign Joint Venture/Build Operate and Transfer
FSL	Full supply level (normal operating level)
FY	Fiscal Year
GE	Google Earth
GMS	Greater Mekong Subregion
GOM	Government of Myanmar
Hka	means river
HPP	Hydropower plant/project
HTCT	HTCT Energy Investment Company Ltd
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IGOEC	International Group of Entrepreneurs Company
JICA	Japan International Cooperation Agency
JV	Joint venture
JVA	Joint venture agreement
LCoE	Levelized cost of energy
MEMP	Myanmar Energy Master Plan
MoA	Memorandum of agreement
MoALI	Ministry of Agriculture, Livestock and Irrigation
MoEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power (now MoEE)
MONREC	Ministry of Natural Resources and Environmental Conservation
MOPF	Ministry of Planning and Finance
MoU	Memorandum of understanding
Nam	means river
NEP	Myanmar National Electrification Plan
NHPC	National Hydroelectric Power Corporation
NPEP	National Power Expansion Plan

PDP	Project development permit
PDR	People's Democratic Republic
PRC	People's Republic of China
RCC	roller-compacted concrete
SEA	Strategic Environmental Assessment
SES	Sustainable energy sector
SPIC	China State Power Investment Corporation (formerly CPI)
TEI	Trust Energy Investments, Pte. Ltd. of Singapore
THA	Thailand
u/s	Up stream
UACBH	Upstream Ayeyarwady Confluence Basin Hydropower Co.
UNFCC	United Nations Framework - Convention on Climate Change
WB	World Bank
WWF	World Wide Fund for Nature
YEIG	Yunnan Energy Investment Group
YNIC	Yunnan International Company Ltd.

UNITS

GWh	gigawatt-hours = million kilowatt-hours
hm^3	million cubic meters
km	kilometers
km^2	square kilometers
kV	kilovolt = 1,000 volt (V)
kW	kilowatt = 1,000 watt (W)
kWh	kilowatt-hour
$l/s/km^2$	liters per second per square kilometer (mean annual flow divided by catchment area)
m	meters
m^3/s	cubic meters per second
MVA	mega-volt-ampere
MW	megawatt = 1 million watts

DEFINITIONS

Basin	refers to main river basins in Myanmar
Power plant	means an existing power plant or one under construction, and includes all main components (dam, headrace and powerhouse)
Power project	means a power plant at pre-investment stage, i.e. before main construction has started
Sub-basin	refers to subdivision of a basin along the main stream
Watershed	refers to the catchment of a tributary to a sub-basin

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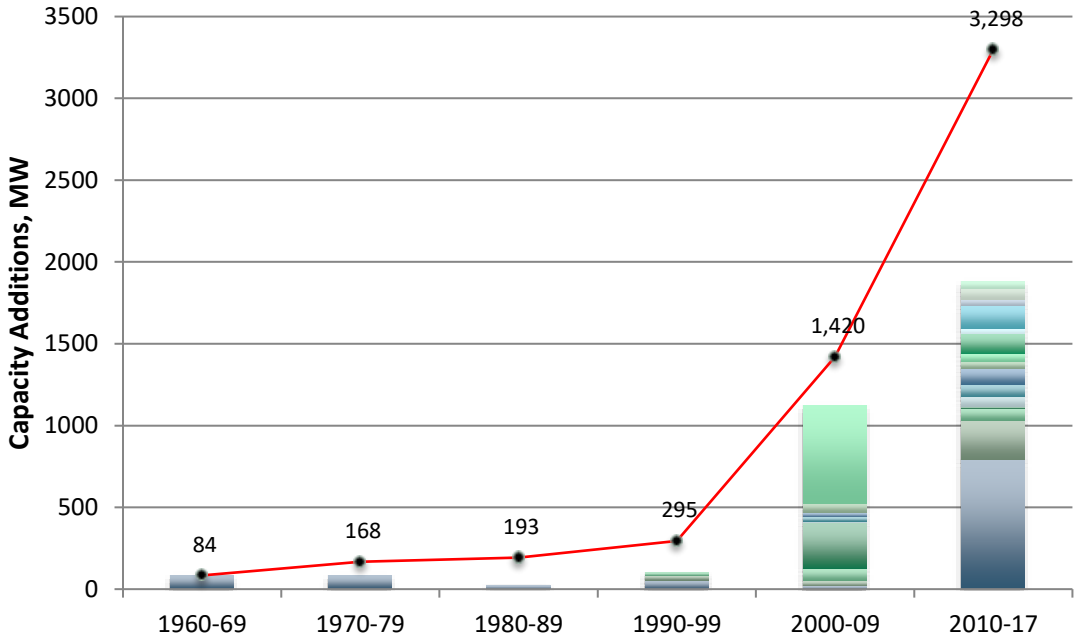
1 EXECUTIVE SUMMARY

This chapter outlines the status of hydropower development in in Myanmar. In absence of a hydropower policy or plan in Myanmar, the Strategic Environmental Assessment (SEA) will assess the existing hydropower plants and planned projects in the major river basins and sub-basins.

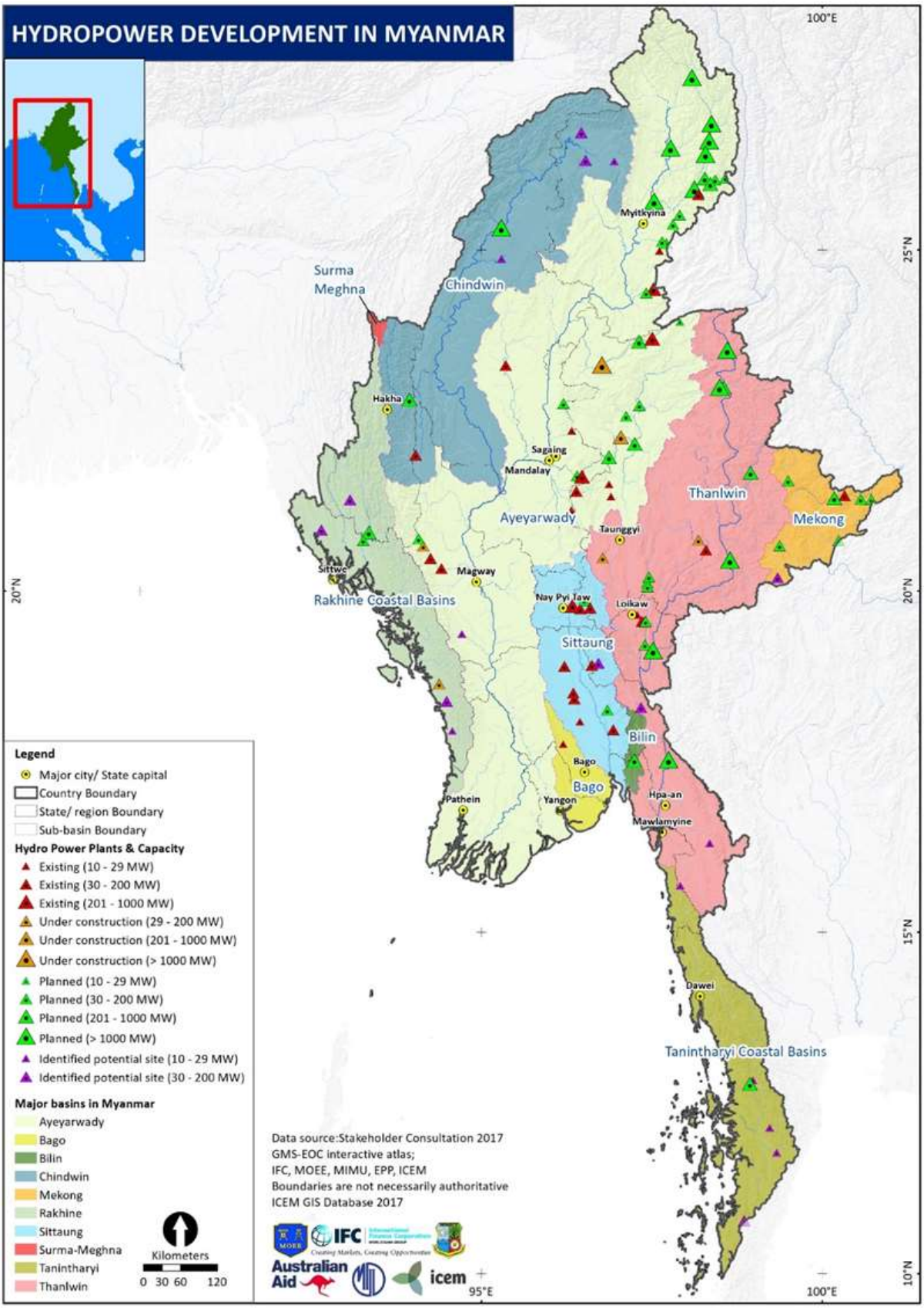
Sixteen years after the World's first hydropower plant was commissioned in 1882 in Wisconsin, USA, the first hydropower plant in Myanmar was built on the Yeni River with an installed capacity of 460 kilowatt (kW). Only in 1960 was the first large hydropower plant completed in Myanmar, the first phase of the 168 megawatts (MW) Baluchaung II hydropower plant, taking advantage of part of the available 650-meter (m) head at Lawpita Falls in the Thanlwin Basin south of Loikaw in Shan State. Development of large hydropower power continued, accelerating after 2000, and has now reached about 3,331 MW, including small and mini hydropower plants. Twenty-nine power plants are in the range 10 MW - 790 MW, totalling 3,298 MW (Figure 1.1).

Figure 1.1: Historical Hydropower Capacity Additions



Of the 29 power plants already operating, twelve have been built by the Ministry of Electricity and Energy (MoEE, 1,474 MW), three by the Ministry of Agriculture, Livestock and Irrigation (MoALI, 144 MW) and seven by MoEE and MoALI in cooperation (492 MW). A further four have been built by Myanmar private developers, and three by foreign developers in joint venture with MoEE. Thirteen of the dams already built by MoEE and MoALI are multipurpose dams with irrigation and hydropower (12 MW - 280 MW) being the main uses of the dam. Figure 1.2 shows the locations of existing hydropower plant and planned hydropower projects.

Figure 1.2: Existing and Planned Hydropower Development in Myanmar (>10 MW)



The first local private sector development was the 10.5 MW Mali Creek hydropower plant in Kachin State providing electricity to Myitkyina; the power plant was completed in 2006. The second private

sector power plant, the 600 MW Sweli 1 HPP, was completed in 2009 by YUPD, PRC, in joint venture with MoEE. Since then, private sector has completed 677 MW (238 MW by local developers and 339 MW by foreign developers). See Table 1.1.

An additional six power plants are under construction with an installed capacity of 1,564 MW, the largest being the 1,050 MW Shweli 3 hydropower plant in the Ayeyarwady Basin. See Table 1.2:

Table 1.1: Existing Hydropower and Multipurpose Dams

Developer	Hydropower Plant	Investment by	Installed Capacity (MW)	Completed
MoEE	Baluchaung 2	GOM	168	1974
MoEE	Sedawgyi	GOM	25	1989
MoEE	Kinda	GOM	56	1990
MoEE	Baluchaung 1	GOM	28	1992
MoEE	Zawgyi I	GOM	18	1995
MoEE	Zaungtu	GOM	20	2000
MoEE	Keng Tawng	GOM	54	2009
MoEE	Yeywa	GOM	790	2010
MoEE	Shwegyin	GOM	75	2011
MoEE	Kun Chaung	GOM	60	2012
MoEE	Nancho	GOM	40	2013
MoEE	Paung Laung (upper)	GOM	140	2015
MoALI	Kyee Ohn Kyee Wa	GOM	74	2012
MoALI	Myogyi	GOM	30	2015
MoALI	Myittha	GOM	40	2017
MoEE/MoALI	Thapenzeik	GOM	30	2002
MoEE/MoALI	Mone Chaung	GOM	75	2004
MoEE/MoALI	Paung Laung (lower)	GOM	280	2005
MoEE/MoALI	Yenwe	GOM	25	2007
MoEE/MoALI	Ka Baung	GOM	30	2008
MoEE/MoALI	Zawgyi II	GOM	12	2011
MoEE/MoALI	Phyu Chaung	GOM	40	2015
Buga Co.	Mali	Local BOT	10.5	2006
Future Energy	Baluchaung 3	Local BOT	52	2014
Gold Energy	Thauk Ye Khat (2)	Local BOT	120	2014
ESDC	Mongwa	Local BOT	66	2016
YUPD	Shweli 1	F-JV/BOT	600	2009
China Datang	Dapein 1	F-JV/BOT	240	2011
SPIC	Chipwi Nge	F-JV/BOT	99	2013

GOM: Government of Myanmar; BOT: Build, operate and transfer; F-JV: Foreign Joint Venture

Table 1.2: Dams under construction

Developer	Hydropower Plant	Investment by	Installed Capacity (MW)	Scheduled for Completion
MoEE	Keng Tawng (upper)	GOM	51	2020
MoEE	Yeywa (upper)	GOM	280	2021
MoEE	Thahtay	GOM	111	2021
MoALI	Buywa	GOM	42	2018
NeoEnergy Oasis	Baluchaung (upper)	Local BOT	30	2020
EDF SA	Shweli 3	F-JV/BOT	1,050	2021

GOM: Government of Myanmar; BOT: Build, operate and transfer; F-JV: Foreign Joint Venture

There are 69 identified hydropower projects totalling 43,848 MW in various stages of development. Table 1.3 lists the projects being considered by MoEE, and state and regional authorities that can approve the development of projects less than 30 MW that will not be connected to the national grid. Some of the projects listed are at a very early stage of development with no significant data and have been classified merely as "Identified as potential hydropower projects".

Table 1.3: Planned Hydropower and Multipurpose Projects (by basin)

Basin/ Hydropower Plant	Status	Sub-basin	Installed Capacity (MW)	Developer	Country	Investment by
Ayeyarwady						
Myitsone	JVA	Upper Ayeyarwady Mainstem	6,000	CPIYN/AWC	PRC/MYA	F-JV/BOT
Chipwi	JVA	Nmae Hka	3,400	CPI	PRC	F-JV/BOT
Gaw Lan	JVA	Naw Chang Hka	120	YEIG/IGOEC	PRC/MYA	F-JV/BOT
Laza	JVA	Mali Hka	1,900	CPIYN	PRC	F-JV/BOT
Tongxinqiao	JVA	Naw Chang Hka	340	YEIG/IGOEC	PRC/MYA	F-JV/BOT
Hkankawn	MoA	Naw Chang Hka	140	YEIG/IGOEC	PRC/MYA	F-JV/BOT
Khaunglanphu	MoA	Nmae Hka	2,700	CPI	PRC	F-JV/BOT
Lawngdin	MoA	Naw Chang Hka	600	YEIG/IGOEC	PRC/MYA	F-JV/BOT
Pisa	MoA	Nmae Hka	2,000	CPI	PRC	F-JV/BOT
Renan	MoA	Nmae Hka	1,200	CPI	PRC	F-JV/BOT
Wutsok	MoA	Nmae Hka	1,800	CPI	PRC	F-JV/BOT
Dum Ban	MoU	Nmae Hka	130	YBEP/Chan Yinn Khuu	PRC/MYA	F-JV/BOT
Nam Li	MoU	Nmae Hka	165	YBEP/Chan Yinn Khuu	PRC/MYA	F-JV/BOT
Dapein 2	MoU	Dapein	140	DUHD	PRC	F-JV/BOT
Sedawgyi (upper)	GOM Plan	Ma Gyi Chaung	64	MoALI	Myanmar	GOM
Buywa (upper)	GOM Plan	Mone Chaung	150	MoALI	Myanmar	GOM
Mindon	I	Mindon	18	-	-	-

Basin/ Hydropower Plant	Status	Sub-basin	Installed Capacity (MW)	Developer	Country	Investment by
Nam Tu	Local MoU	Myitnge	100	NCEH	Myanmar	Local BOT
Deedoke	MoU	Myitnge	66	Andritz Hydro	Austria	F-JV/BOT
Nam Hsim	MoU	Myitnge	30	PCR/SE	PRC/MYA	F-JV/BOT
Nam Lang	MoU	Myitnge	210	PCR/SE	PRC/MYA	F-JV/BOT
Yeywa (middle)	MoU	Myitnge	700	SN Power	Norway	F-JV/BOT
Nam Tabak I	MoA	Namtabak	141	China Guodian/Tun Thwin Mining	PRC/MYA	F-JV/BOT
Nam Tabak II	MoA	Namtabak	144	China Guodian/Tun Thwin Mining	PRC/MYA	F-JV/BOT
Nam Paw	Covenant	Shweli	20	Great Hor Kham	Myanmar	Local BOT
Shweli 2	MoA	Shweli	520	HIE/AWC	PRC/MYA	F-JV/BOT
Tamanthi	Suspended	Chindwin	1,200	NHPC	India	F-JV/BOT
Manipur	MoU	Manipur	380	CHEC/Sein	PRC/MYA	F-JV/BOT
U Yu Chaung	I	Uyu	12	-	-	-
Ta Nai Hka	I	Chindwin Headwaters 2	15	-	-	-
Ta Rung Hka	I	Chindwin Headwaters 1	150	-	-	-
Tawog Hka	I	Chindwin Headwaters 1	50	-	-	-
Thanlwin						
Nam Hka	MOU	Nam Hka	210	YNIC	PRC	F-JV/BOT
Mantong	MoA	Nam Ma	225	HydroChina/IGOEC	PRC/MYA	F-JV/BOT
La Pha	I	La Pha	20	-	-	-
Myet Taw Chaung	I	Myet Taw Chaung	10	-	-	-
Yunzalin	I	Yunzalin	100	-	-	-
Hawkham (upper)	MoU	Nam Pawn	180	TEI/HCTC	SIN/MYA	F-JV/BOT
Hpak Nam	MoU	Nam Pawn	105	TEI/HCTC	SIN/MYA	F-JV/BOT
Hpi Hseng	MoU	Nam Pawn	45	TEI/HCTC	SIN/MYA	F-JV/BOT
Nam Pawn (lower)	MoU	Nam Pawn	105	TEI/HCTC	SIN/MYA	F-JV/BOT
Nam Pawn (upper)	MoU	Nam Pawn	150	TEI/HCTC	SIN/MYA	F-JV/BOT

Basin/ Hydropower Plant	Status	Sub-basin	Installed Capacity (MW)	Developer	Country	Investment by
KunLong	JVA	Main stem	1,400	Hanergy YN, MPC	PRC/MYA	F-JV/BOT
Hutgyi	MoA	Main stem	1,360	Sinohydro + EGATi+IGOEC	PRC/THA/MYA	F-JV/BOT
Naopha	MoA	Main stem	1,200	HydroChina/IGOEC	PRC/MYA	F-JV/BOT
Ywathit	MoA	Main stem	4,000	CDOI/STH	PRC/MYA	F-JV/BOT
Mong Ton	MoU	Main stem	7,000	Three Gorges+EGAT	PRC/THA	F-JV/BOT
Sittaung						
Bawgata	Local MoU	Bawgata	160	Thoolei	Myanmar	Local BOT
Paung Laung (middle)	MoU	Paung Laung	100	Energized Myanmar	SIN	F-JV/BOT
Thauk Ye Khat 1	I	Other Sittaung	150	-	-	-
Mekong						
Mong Hsat	Local MoU	Nam Hkoke	20	Suntac Power Co.	Myanmar	Local BOT
Nam Hkok	I	Nam Hkoke	30	-	-	-
Nam Lin	Local MoU	Nam Lin	36	MAM	Myanmar	Local BOT
He Kou	MoU	Nam Lwe	138	YNIC	PRC	F-JV/BOT
Keng Tong	MoU	Nam Lwe	170	YNIC	PRC	F-JV/BOT
Keng Yang	MoU	Nam Lwe	70	YNIC	PRC	F-JV/BOT
Suo Lwe	MoU	Nam Lwe	240	YNIC	PRC	F-JV/BOT
Rakhine State Coastal Basins						
Lemro 1	MoU	Lemro	600	Tractabel	France	F-JV/BOT
Lemro 2	MoU	Lemro	90	Tractabel	France	F-JV/BOT
Kyein Ta Li	I	Kyein Ta Li	28	-	-	-
Mi Chaung	I	Kaladan	200	-	-	-
Saing Din	I	Saing Din	77	-	-	-
Than Dwe	I	Than Dwe	39	-	-	-
Taninthayi Region Coastal Basins						
Taninthayi	Suspended	Tanintharyi	600	Italian-Thai	Thailand	F-JV/BOT
Sar Ra Wa Chaung	I	Tanintharyi	11	-	-	-
Tha Gyet Chaung	I	Tanintharyi	20	-	-	-
Thein Kun Chaung	I	Tanintharyi	25	-	-	-
Glohong Kra	I	Glohong Kra	40	-	-	-

Basin/ Hydropower Plant	Status	Sub-basin	Installed Capacity (MW)	Developer	Country	Investment by
Belin						
Belin	Local MoU	Bilin	280	HCDG	Myanmar	Local BOT

GOM: Government of Myanmar; BOT: Build, operate and transfer; F-JV: Foreign Joint Venture; MoU: Memorandum of Understanding; MoA: Memorandum of Agreement; JVA: Joint Venture Agreement; I: identified for hydropower development.

2 INTRODUCTION

This chapter outlines the status of hydropower development in Myanmar. In absence of a hydropower policy or plan in Myanmar, the SEA will assess the existing hydropower plants and planned projects in the major river basins and sub-basins. The analysis firstly covers how hydropower has contributed to meeting power supply and demand at the national level and provides an overview and power transmission and distribution. The analysis then drills down to the status of existing plants and planned projects at a basin-by-basin level. The initial review of existing and planned HPPs included projects equal to 10 MW and greater, and includes information on the development process and key technical data for each project:

- **Development process**: information on the investment status, date EIA or feasibility was submitted, foreign or local investment and year the project will be commissioned according to information provided by MoEE; and
- **Key technical data**: Installed capacity (MW), generation (GWh/year), dam height, total storage, reservoir area, retention period, type (e.g. run-of-river, storage, multi-purpose) and export (%).

Obtaining accurate GIS layers for the existing and proposed HPPs was a critical step in the baseline phase as it forms the basis for spatial analysis in the SEA. The most important information is the GIS coordinates (i.e. location) of the dam, and if available, the location of the powerhouse when not at the foot of the dam. In this chapter the objective was to identify the physical impacts of each hydropower plant as far as the information was available (inundation area and length, storage, dried-out river stretches, etc.). This is an essential piece of information to assess the impact, and cumulative impacts of projects in cascades or within a basin or sub-basin. The team will overlay the location of existing and planned HPPs on the basins and sub-basins to show the past and future trends in each of the key themes of the SEA: geomorphology and sediment, biodiversity, fisheries and aquatic ecology, economics, social and livelihoods and conflict in other chapters of this and subsequent reports. The following paragraphs and Annex 1 outline the process for developing the hydropower (HPP) database with MoEE and other stakeholders.

The main source of information on the development process and key technical data was primarily through a series of consultations with MoEE and direct discussions with MONREC, MoALI, MOPF and other Ministries. To compile an accurate register of projects, the SEA team also sought information through meetings with hydropower developers and from other sources for example, presentations, newspaper articles, reports and EIAs, much of it available from the internet (see footnotes). Information garnered from those latter sources was then reviewed for accuracy with the MoEE technical advisors.

At the start of the SEA study, the team reviewed the list of existing and planned HPPs provided by MoEE. The team also identified projects in various other lists available from the Internet and international organisations. In total, 135 existing and proposed single purpose hydropower dams and multipurpose dams with a hydropower component with an aggregate installed capacity of 64,600 MW and irrigation dams were identified. At a workshop with MoEE and other Ministries in December 2016, this list was reduced to 85 officially recognised dams consisting of single purpose hydropower and multipurpose dams with a hydropower plant 10 MW or greater. The original list had included multipurpose dams with power plant with a capacity less than 10 MW, and projects that had been identified in earlier years that MoEE informed were no longer in the official project list. Later the list grew to 104 HPPs after MoEE provided the names, locations and capacities of potential hydropower projects that have still to be studied at a more detailed level. To better analyse the data of the projects in the list, the SEA Consultant sought to prepare a HPP database which underwent the following stages: design of database structure, collection of data, quality control of information received, analysis and reporting, further information is provided in Annex 1. The HPP database forms the basis for the trend and spatial analysis in the SEA.

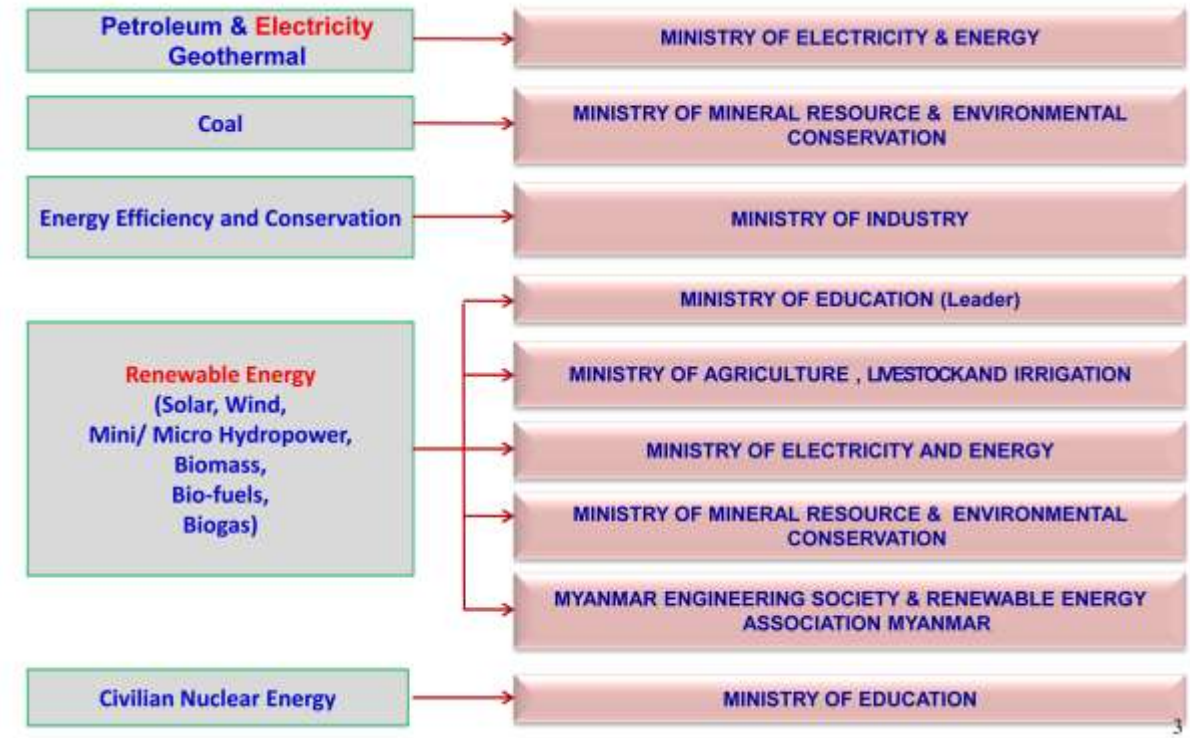
3 MYANMAR POWER SECTOR

3.1 Institutional Framework

This section summarizes the institutional framework of the Myanmar power sector. Several key ministries manage the sector (Figure 3.1):

- Ministry of Electricity and Energy (MoEE),
- Ministry of Mineral Resources and Environmental Conservation,
- Ministry of Industry,
- Ministry of Education, and
- Ministry of Agriculture, Livestock and Irrigation.

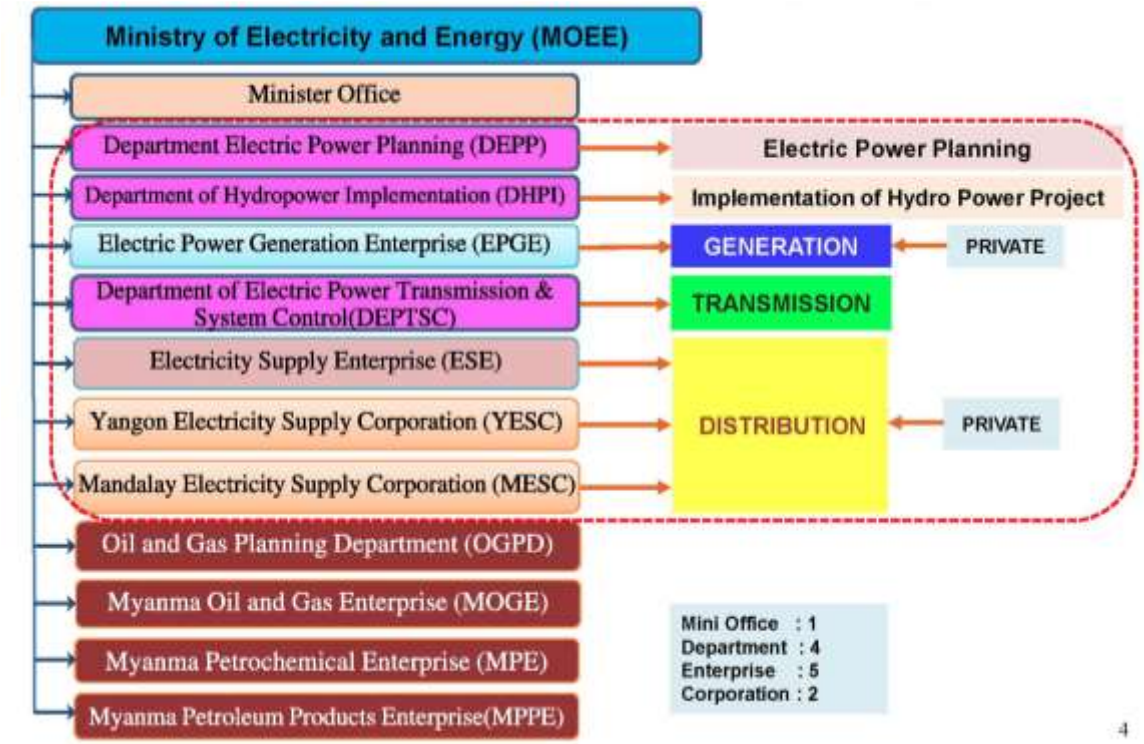
Figure 3.1: Institutional Framework of Myanmar Power Sector



Source: MoEE, Power Development Opportunities in Myanmar, Myanmar Investment Forum 2017, 6 - 7 June 2017.

MoEE, the principal ministry responsible for the hydropower sub-sector, consists of several departments and enterprises (Figure 3.2). The Department Electric Power Planning (DEPP) is responsible for planning, and has been assigned the main MoEE counterpart for the SEA.

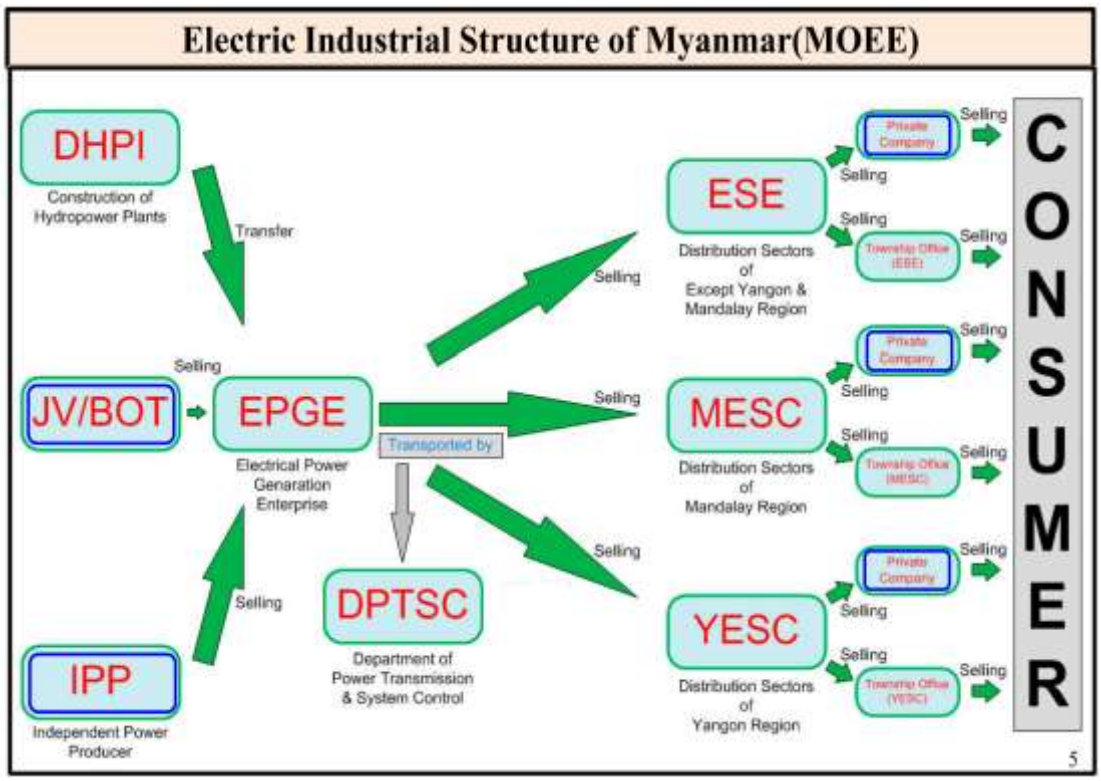
Figure 3.2: Ministry of Electricity and Energy



Source: MoEE, Power Development Opportunities in Myanmar, Myanmar Investment Forum 2017, 6 - 7 June 2017.

Figure 3.3 shows the relationship among the various parties involved in generating, transmitting and selling power to consumers.

Figure 3.3: The flow of electricity from generator to consumer



Source: MoEE, Power Development Opportunities in Myanmar, Myanmar Investment Forum 2017, 6 - 7 June 2017.

The following laws and regulations specifically govern the power sector:

- Electricity Law (2014)
- Electricity Rule (2015)
- Myanmar Investment Law (2016)
- The Environmental Conservation Law (2012)
- Environmental Impact Assessment (EIA) Procedures (2015)
- Electricity Regulations (being prepared under ADB financing)
- Grid Code (being prepared under ADB/Norwegian financing)

A state/region government can regulate HPPs with an installed capacity up to 30 MW and not connected to the national power grid. The Constitution, 4a of schedule 2 (refer to session 188) stets that: "*Medium and small scale electric power production and distribution that have the right to be managed by the Region or State not having any link with national power grid, except large scale electric power production and distribution having the right to be managed by the Union*". Small scale electrical projects are defined as up to 10 MW capacity in the Electricity Law 2014, while mid-sized electrical projects are defined as 10 < to ≤ 30 MW. MoEE regulates large-scale projects (greater than 30 MW).

Specific to the SEA, the EIA procedures require that "*(3) Pursuant to Section 21 of the Law and Articles 52, 53 and 55 of the Rules, all Projects and Project expansions undertaken by any ministry, government department, organization, corporation, board, development committee and organization, local government or authority, company, cooperative, institution, enterprise, firm, partnership or individual (and/or all Projects, field sites, factories and businesses including expansions of such Projects, field sites, factories and businesses identified by the Ministry, which may cause impact on environmental quality and are required to obtain Prior Permission in accordance with Section 21 of the Law, and Article 62 of the Rules) having the potential to cause Adverse Impacts, are required to undertake IEE or EIA or to develop an EMP, and to obtain an ECC in accordance with this Procedure*."

It further states that *"(8) Any Project already in existence prior to the issuance of the Rules, or the construction of which has already commenced prior to the issuance of the Rules, and which, in either case, shall be required to undertake, within the timeframe prescribed by the Department, an environmental compliance audit, including on-site assessment, to identify past and/or present concerns related to that Project's Environmental Impacts, and to:*

a) develop an EIA or IEE or EMP;

b) obtain an ECC; and

c) take appropriate actions to mitigate Adverse Impacts in accordance with the Law, the Rules, and other applicable laws."

The EIA Procedures paras 38 and 65 states that "*Not later than fifteen (15) days after submission of the IEE/EIA Report to the Department, the Project Proponent shall disclose the IEE/EIA Report to civil society, PAPs, local communities and other concerned stakeholders: (i) by means of national media (i.e. newspapers); (ii) the website(s) of the Project or Project Proponent; (iii) at public meeting places (e.g. libraries, community halls); and (iv) at the offices of the Project Proponent*."

The EIA procedures classify projects as shown in Table 3.1.

Table 3.1: Criteria to determine whether to apply IEE or EIA in hydropower projects

Hydropower Plants	Carry out IEE if any apply	Carry out EIA if any apply
Installed Capacity (P)	1 MW ≤ P < 15 MW	≥15 MW
Reservoir volume at FSL (V)	V < 200,000 m^3	≥ 200,000 m^3
Reservoir Area at FSL (A)	A < 4 km^2	≥ 4 km^2

The above clearly indicates that most projects being considered in the SEA should prepare or have prepared an IEE, EIA or EMP as appropriate to obtain an Environmental Compliance Certificate (ECC). The IEE, EIA or EMP should have been made public. However, the SEA team found few such documents available in the Internet.

3.2 Power Supply

Electricity was introduced early to Myanmar. In 1937, a United States Department of Commerce publication listed 106 power plants in Myanmar, with six over 1 MW and several under 10 kW. The largest belonged to Burmah Oil Company, the Yenangyaung Plant of 20 MW in Magway Region. The 16.5 MW plant of the Rangoon Electric Tramway and Supply Company established in 1905 (and in 1953 nationalised as part of the Rangoon Electric Supply Board) supplied alternating current, while the great majority of the power plants using fossil fuel throughout the country supplied direct current at 220 Volt (V). The third largest was at Mansam near Namtu, Shan State (10 MW). Many power plants were destroyed during the Second World War.[1]

The first hydropower plant (460 kW) was built on the Yeni River, Mogok in 1898, and 16 years after the first hydroelectric plant in the World was built in Wisconsin, USA. During the 1950s, Japanese engineers surveyed the country to develop hydropower. These and other studies have estimated that Myanmar has more than 100,000 MW of capacity potential. The first large-scale hydropower plant was built in the Thanlwin Basin at the Lawpita Falls on the Baluchaung.[2] The first phase of this run-of-river 84 MW power plant (Baluchaung II) was completed in 1960; the second phase was completed in 1974 with a further 84 MW. Since then hydropower has been the main source of electricity in Myanmar. In the 1980s an additional 25 MW were built in other parts of the country, followed by three projects totalling 102 MW in the 1990s, eight projects totalling 1,125 MW in 2000-09, and 15 projects totalling 1,878 MW in 2011-17 (to date). Twenty-nine hydropower projects larger than 10 MW now total 3,298 MW. Additionally 32 mini hydropower plants totalling 33.3 MW have been built in connection with irrigation dams or as part of off-grid rural electrification.

The total installed capacity in the first half of 2017 was 5,389 MW, of which 3,255 MW (60.4%) was from hydropower, 1,920 MW (35.6%) from gas, 120 MW (2.2%) from coal and 94.3 MW (1.75%) from diesel.[3,4] MoEE[5] owns about 60% of the total installed capacity, the rest being owned by private sector as IPP or joint venture (JV) with MoEE. There has been a significant increase in private participation in the power sector growing from 6.2% of annual generation in the fiscal year (FY) 2008-09 to 48.4% in FY2016-17. Presently, about 1,692 MW of hydropower installed capacity, 649 MW of gas-fired power projects and 470 MW of solar power is under construction or about to start construction.

Due to its distinct wet and dry seasonal pattern, Myanmar experiences significant fluctuations in the supply of, and demand for, electricity. Its existing base load generation mix is dominated by hydropower, which reaches peak capacity towards the end of the wet season and tails off to produce shortages during the dry season. Available capacity is about 50% of installed capacity due to poor

[1] Russel Andrus, J. *Burmese Economic Life,* 1948

[2] The following words mean river or stream in Myanmar: Chaung, Hka and Nam. Therefore when naming a river with these words either attached or separate from the river name, the word "river" in English will be omitted. For example Baluchaung, Nam Li, Mali Hka will not be referred to as Baluchaung River, Nam Li River or Mali Hka River.

[3] MoEE, *Power Development Opportunities in Myanmar,* Myanmar Investment Forum 2017, 6 - 7 June 2017.

[4] There is a slight difference between MoEE's data in the presentation of 6 - 7 June 2017 and the HP Database because the database includes some State/Regional projects and has used data provided by developers.

[5] Formerly known as Ministry of Electric Power (MoEP). In this report MoEP is referred to under its new name MoEE.

maintenance. Two hydropower plants totalling 53 MW, Baluchaung 1 and Sedawgyi, are presently under rehabilitation under Japanese ODA loans. Seven older hydropower plants[6] totalling 528 MW are scheduled for rehabilitation. In addition, one gas-fired (GT) power plant (57 MW Thaketa) is being rehabilitated under a JICA loan.

3.3 Power Demand

Myanmar has the lowest grid-connected electrification rate in South East Asia at 38% in 2016-17, compared to only 16% in 1995. All 422 townships in the country have been electrified (100%), while only 31,781 villages (49.8%) have access to electricity.[7] Within the country, Yangon City had the highest electrification ratio in 2016 of approximately 78%, followed by Loikaw (46%), Mandalay (40%), and Nay Pyi Taw (39%). The remaining rural areas are still poorly electrified, averaging less than 20%. In Kayin state and Tanintharyi region, the electrification rate remains under 10%. The GOM policy is to achieve 100% electrification by 2030.

In terms of per capita electricity consumption, Myanmar is ranked one of the lowest countries in the world, with 300 kilowatt-hours (kWh) per capita (2016-17), which was much lower than the 2014 world average per capita consumption of 3,128 kWh.[8] Only Nepal has a lower per capita consumption in Asia.

From 2000-01 to 2009-10 annual demand for electricity grew at about 4.8% per year from 3,268 gigawatt-hours (GWh) to 5,000 GWh. Since then demand has accelerated, and from 2009-10 to 2013-14 demand for electricity grew an average of 17.6% per year to 11,252 GWh compared to annual GDP growth of 7.2% from 2011 to 2014. In FY2016-17 demand reached 15,355 GWh. Figure 3.4 shows that hydropower generation followed the total consumption curve closely after 2009-10 up to 2013-14. As the economy grows and poverty reduction accelerates, demand for electricity is expected to rise by 9.6% annually to 49,924 GWh in 2030.[9] MoEE has prepared a power demand forecast with the assistance of JICA-financed consultants that shows that by 2030 power demand would reach between 9,100 MW (low-case scenario) and 14,542 (high-case scenario) corresponding to an average growth of 8.1% and 11.7% respectively.[10] The projection, starting in 2013, projected a peak load in 2017 in the range of 2,884 MW to 3,192 MW. On 23 May 2017 peak load reached 3,075 MW.[11]

[6] Zaungtu (commissioned in 2000), Zawgyi II (2011), Ye Nwe (2007), Kinda (1990), Mone Chaung (2004), Thapenzeik (2002), and Kabaung (2008)

[7] MoEE, *Power Development Opportunities in Myanmar,* Myanmar Investment Forum 2017, 6 - 7 June 2017

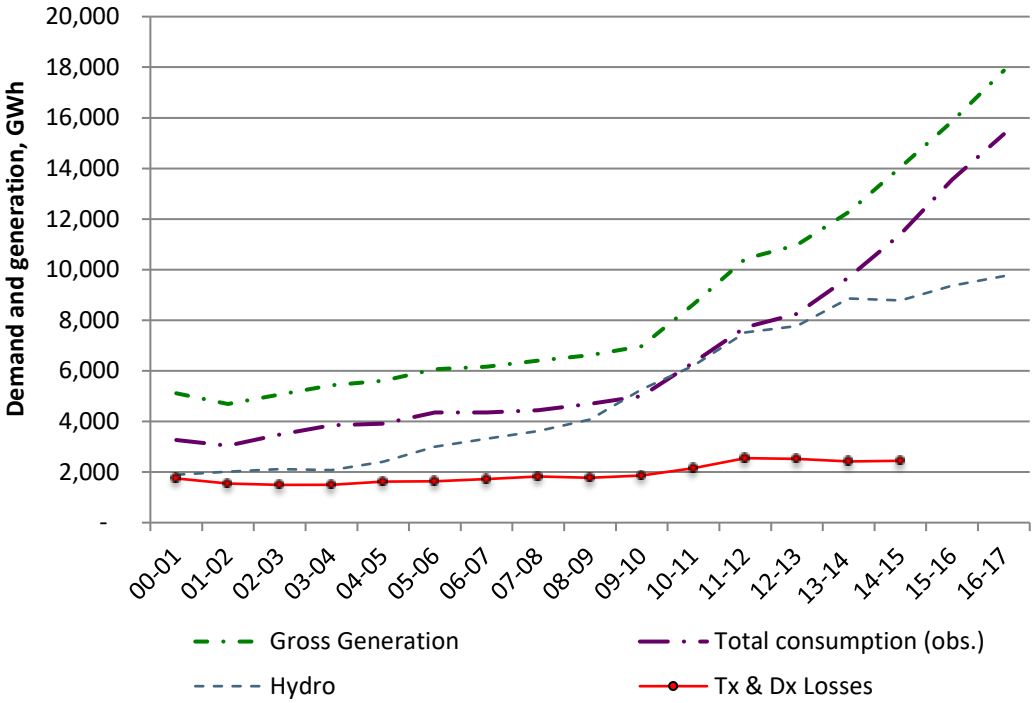
[8] http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

[9] ADB, Report and Recommendations of the President to the Board of Directors: Proposed Loan to the Republic of the Union on Myanmar: Power Transmission Improvement Project, October 2015.

[10] MoEE, *Power Development Opportunities in Myanmar,* Myanmar Investment Forum 2017, 6 - 7 June 2017

[11] MoEE, *Power Development Opportunities in Myanmar,* Myanmar Investment Forum 2017, 6 - 7 June 2017.

Figure 3.4: Demand and generation growth



Note: As of writing, loss data was not confirmed for 2015-2017

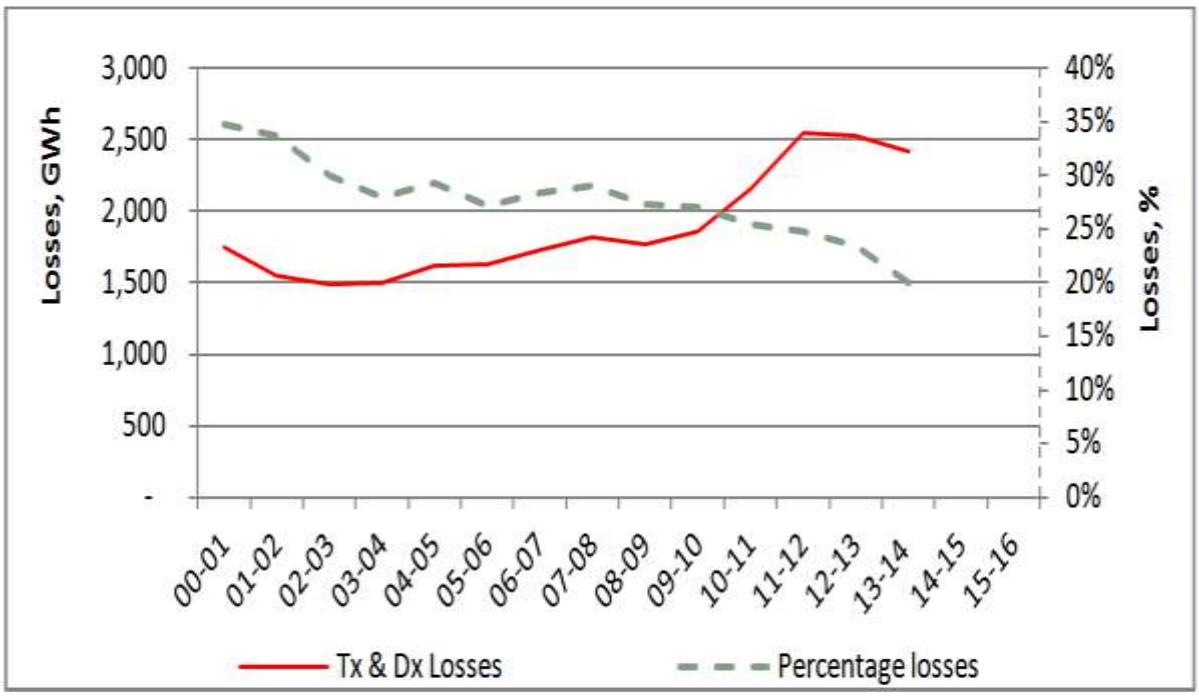
Since 2000, there has been a large gap between demand and generation, the difference being due to transmission and distribution losses and available capacity.

Figure 3.5 shows that in 2013-14, losses were very large at 20% of generation or in absolute terms about 2,400 GWh. In relative terms, losses fell from more than 35% in 2000-01. However, in absolute terms losses have increased by 1,000 GWh from about 1,500 GWh. As a comparison, generation by gas in 2014-15 was 2,794 GWh, i.e. about 85% of gas generation went to covering losses. On the demand side, residential consumption in 2014-15 was 2,699 GWh, the same order of magnitude as losses.

Figure 3.6 shows the generation by the various sources of electricity. Hydropower electricity generation has grown on average 10.4% annually from about 2,000 GWh in 2000-01 to 9,744 GWh in 2016-17. The growth in other sources of electricity remained constant up to 2013-14. However, generation with gas has since then increased from an average of about 1,200 GWh to 8,052 GWh in 2016-17. Generation by coal has reduced from below 1,000 GWh/year to less than 10 GWh. Diesel generation in off-grid systems (61 GWh) exceeds that of coal generation, but is expected to fall as the grid expands. From around 2006-07 to 2013-14, losses were about the same as the generation from gas turbines.

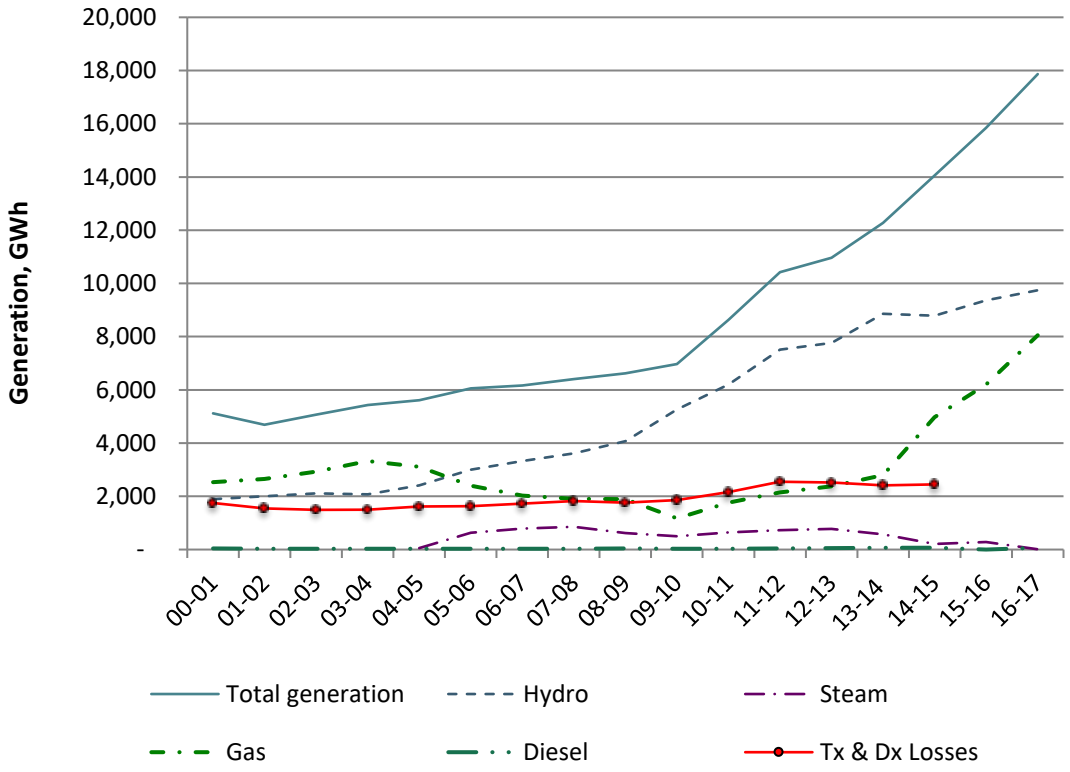
Figure 3.6 shows the generation by the various sources of electricity. Hydropower electricity generation has grown on average 10.4% annually from about 2,000 GWh in 2000-01 to 9,744 GWh in 2016-17. The growth in other sources of electricity remained constant up to 2013-14. However, generation with gas has since then increased from an average of about 1,200 GWh to 8,052 GWh in 2016-17. Generation by coal has reduced from below 1,000 GWh/year to less than 10 GWh. Diesel generation in off-grid systems (61 GWh) exceeds that of coal generation, but is expected to fall as the grid expands. From around 2006-07 to 2013-14, losses were about the same as the generation from gas turbines.

Figure 3.5: Transmission and distribution losses



Note: As of writing loss data was not available for 2014-2016

Figure 3.6: Generation sources and losses



Note: As of writing loss data was not confirmed for 2015-2017

3.4 Power Transmission and Distribution

Myanmar's transmission system comprises a network of 4,445 kilometers (km) of 230 kilo-volt (kV), 2,179 km of 132 kV and 4,678 km of 66 kV transmission lines, and 10,308 mega-volt-ampere (MVA) in substation capacity. These lines mainly transmit power from the central parts of Myanmar, where the hydropower plants are, southwards to the load centers in Yangon and Mandalay. The distribution voltages comprise 33 kV, 11 kV and 6.6 kV, although the latter will be replaced in favour of 11 kV.

The Asian Development Bank (ADB),[12] the Government of Japan,[13] the International Finance Corporation (IFC)[14] and the World Bank (WB)[15] are the main supporters of transmission and distribution development. Ten transmission lines with a length of 965 km at 230 kV voltage level and a substation capacity of 1,900 MVA, and 13 transmission lines with a length of 925 km at 66 kV voltage level and a substation capacity of 155 MVA is under construction. The ADB is providing financing to the 230-kV power transmission ring in Yangon, including 230 kV transmission line and substations. The WB's IDA credit of $400 million will finance activities that combine investment and capacity building in-grid and off-grid electrification. The project consists of three components that by 2021 will benefit about 1.2 million households through: (a) grid extension at medium and low voltage level; (b) about 457,000 households served with solar power in off-grid systems and 35,500 households connected to mini-grids, including contributing to IFC's proposed Lighting Myanmar programme; and (c) technical assistance to support MoEE and the Ministry of Livestock, Fisheries and Rural Development.

A 454-km long 500-kV transmission line with corresponding 1,500 MVA substation capacity is under implementation from the hydropower rich north (Meiktila, Mandalay) to south (Yangon) through bilateral assistance. The first section of 146 km from Meiktila (in Mandalay) to Taungoo, financed by the Government of Serbia, is almost complete. The Government of the Republic of Korea has confirmed the financing of the 188 km middle section between Taungoo and Karmarnat, and the Government of Japan will finance the last 120 km section to Hlaingtharyar in Yangon.[16]

There are two high voltage transmission links between Myanmar and the People's Republic of China (PRC) on the proposed Greater Mekong Subregion (GMS) North-South Economic Corridor which was responsible for about 78% of cross border trade between Myanmar and neighbouring countries out of 15 locations:[17,18]

- One link of 500 kV AC transmission line 8.6 km long to the Myanmar-PRC border established in 2011 between the 240 MW Dapein 1 hydropower plant and a substation (s/s) in Dayingjiang in Yunnan Province.
- One double circuit 23 km long link of 220 kV transmission line to the Myanmar-PRC border established in 2008 between the 600 MW Shweli 1 hydropower plant and Hannong s/s in Yunnan Province.

On 26 August 2008, China Southern Power Grid Yunnan International (YNIC) started buying power from Shweli 1 and Dapein 1 hydropower stations. Up to 31 December 2015, the cumulative power purchase transmitted to the Yunnan grid reached 12,471 GWh.[19]

On 16 February 2015, a 39.1 km 110 kV transmission and transformer project connecting Menglong (Yunnan) with Keng Yang in the Nam Lwe sub-basin of the Mekong was ready for commercial operation. However, due to lack of intergovernmental agreement between GOM and PRC, the line is not yet operational.

[12] https://www.adb.org/projects/documents/mya-power-transmission-improvement-project-rrp
[13] https://www.jica.go.jp/english/news/press/2014/150326_02.html
[14] http://ifcext.ifc.org/ifcext/pressroom/IFCPressRoom.nsf/0/1B5255A8588BD90B85257C8D000C1840
[15] http://projects.worldbank.org/P152936?lang=en
[16] ADB, Myanmar Energy Sector Assessment, Strategy, and Road Map, December 2016
[17] ADB, Greater Mekong Subregion - Energy Sector Assessment, Strategy, And Road Map, June 2016
[18] ADB, Review of configuration of the Greater Mekong Subregion economic corridors, November 2016
[19] http://www.ynic.csg.cn/en/Main_Businesses/Cross_border/201606/t20160612_387.html

On 5 November 2015, YNIC signed an agreement with the Ronglin Co., Ltd. of the Nandeng Special Region in the Wa Special Region (Shan State) for purchase and sales of electricity. According to the plan, a 110 kV transmission line would be constructed to connect Mangka in China with Nandeng in Myanmar by 30 June 2016, after which power would be transmitted to the Nandeng Special Region. The bilateral cooperation was estimated to last at least 20 years, and the power transmitted would be no less than 2 tera-watt hours in the first 10 years of the cooperation period.[20] Like the transmission line to Keng Yang described above, the line is awaiting intergovernmental agreement between GOM and PRC before it can be energized.

[20] http://www.ynic.csg.cn/en/Major_Events/201606/t20160612_394.html

4 HYDROPOWER DEVELOPMENT

The scope of this chapter on hydropower development covers power sector development in Myanmar at a national level and how hydropower has contributed to meeting demand to mid 2017.

4.1 Project Development Process

The first local private sector development was the 10.5 MW Mali Creek hydropower plant in Kachin State providing electricity to Myitkyina; the power plant was completed in 2006. The second private sector power plant, the 600 MW Sweli 1 HPP, was completed in 2009 by YUPD, PRC, in joint venture with MoEE. Since then, private sector has completed 677 MW (238 MW by local developers and 339 MW by foreign developers). Up until around 2011, projects were allocated to private sector companies based on bilateral negotiations between developers and the Government. Private sector development of hydropower projects[21] has relied on companies proposing projects directly to the Government. The location and type of project either comes from previous hydropower studies or identified by the company. For projects 30 MW or larger the source of funds determines the type of contractual arrangement - i.e.:

- Sole investment - financed by the GOM through either MoEE or MoALI;
- Local Build Operate and Transfer (BOT) - developed by Myanmar private sector company; and
- Foreign Joint Venture (JV)/BOT - developed by foreign company in JV with local company and MoEE for BOT.

Regional or state governments can approve hydropower projects under 30 MW, but if a project is to be connected to the national grid, Section 4 Article 9 of the Electricity Law (2014) requires approval by the Union Government in consultation with the relevant ministries responsible for the power sector.

The project development process has four main consecutive steps ending in the following progressive agreements that give the developer the right to move the project to the next stage:

1. Memorandum of Understanding (MoU);
2. Memorandum of Agreement (MoA);
3. Joint Venture Agreement (JVA); and
4. Project Development Permit (PDP).

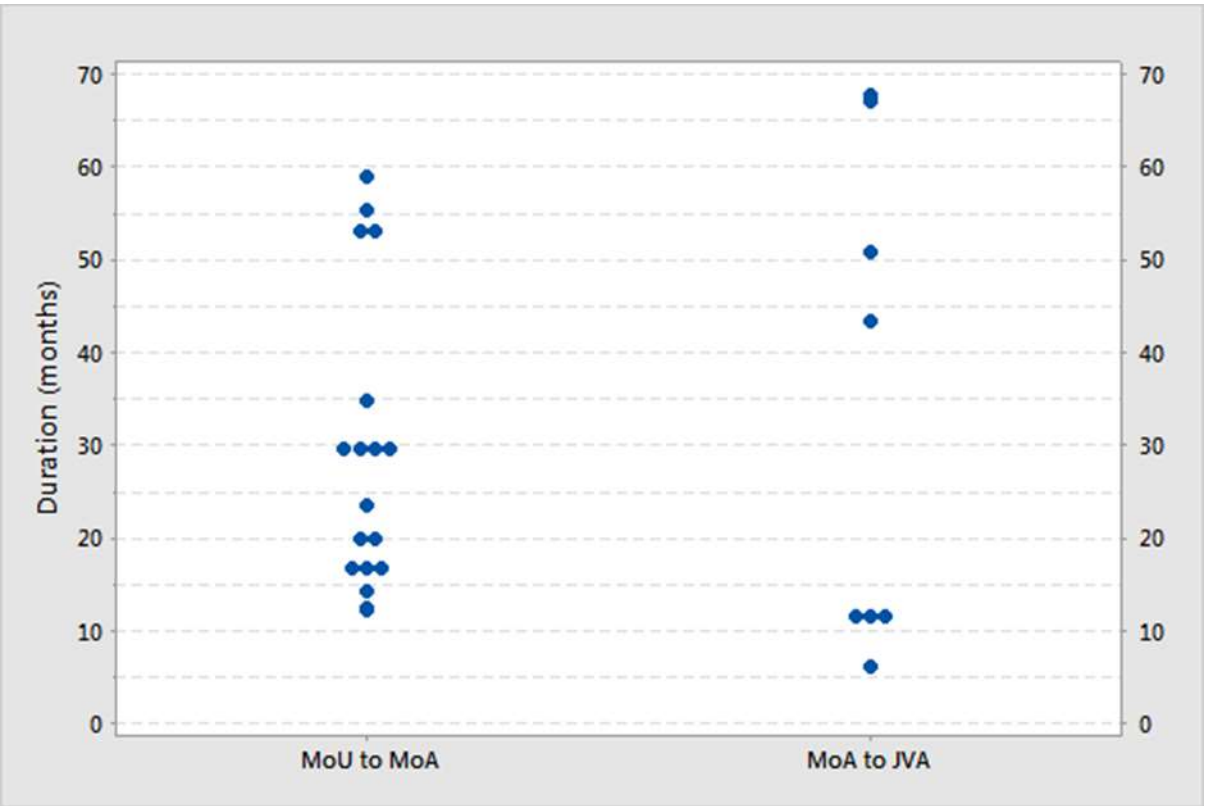
Figure 4.1 shows the duration between MoU and MoA, and between MoA and JVA for selected projects that appear on the HPP database prepared by SEA team and MoEE. For 18 of the projects, the duration between a MoU signature and MoA signature varied from as little as 12 months to 59 months, with half of the projects taking less than 27 months. The work that needs to be done during this period includes conducting a feasibility study and environmental and social impact assessment (ESIA), determining the financial viability of the project and preliminary negotiations on the power purchase agreement (PPA).

In the search for project information on projects that have reached the MoA stage, the SEA team attempted to find EIAs that should have been completed, but was unable to do so.

Of the eight projects that have reached JVA stage, it took four projects six to 11 months to sign the JVA, while the other four ranged from 45 to 67 months.

[21] The first private sector projects to be developed under a Foreign JV/BOT arrangement were the Shweli 1 and Dapein 1 hydropower plants, completed in 2002 and 2007 respectively. Not included in Figure 4.1.

Figure 4.1: Duration between MoU and MoA, and between MoA and JVA for selected projects

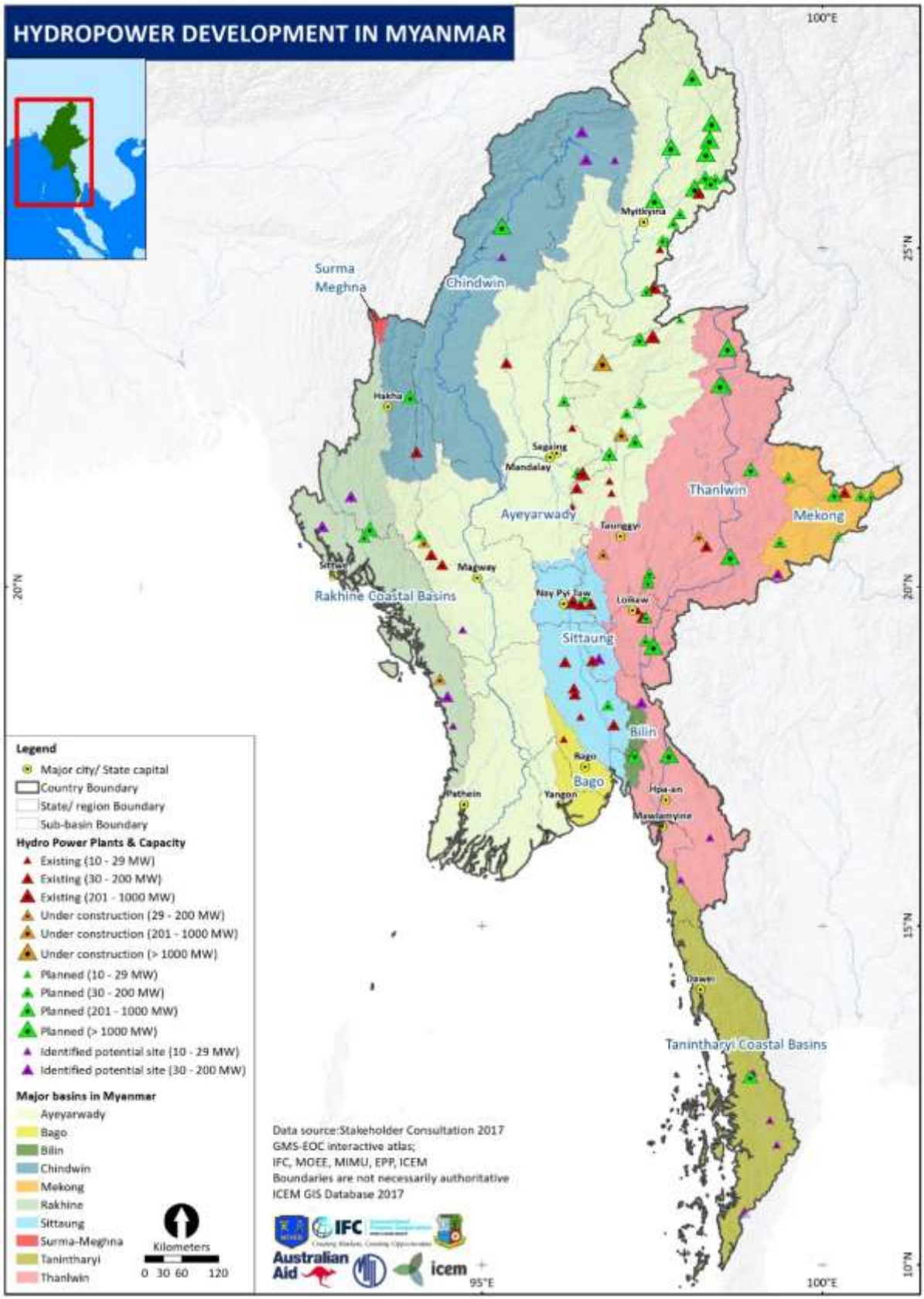


In 2011, the Myitsone hydropower project in the Ayeyarwady Headwaters was suspended by the Government due to local opposition to the project. The project was expected to inflict significant social and environmental impacts. Questions about building such a large project on the mainstream Ayeyarwady River also resulted in national and international concern. The project is one of six hydropower projects being proposed by China State Power Investment Corporation (SPIC). Another project also being proposed by SPIC, the Chipwi hydropower project, had reached the JVA stage and preparatory works had started. However, local opposition to the project resulted in works at the project site being stopped in 2010. Therefore, the other projects being proposed by SPIC have also been put on hold until the Government makes a decision. Accordingly, the commissioning dates indicated in the HPP database and this report are unlikely to be achieved for many of the proposed projects. Additionally, a slower electricity demand growth in PRC may also impact on SPIC's and the other Chinese developers' decision to proceed with any of the export-oriented projects assigned to them.

4.2 Project Development Status

Figure 4.2 shows the distribution of existing power plants and planned projects throughout Myanmar. Section 4 below shows maps for each of the basins describing the hydropower development in each basin and sub-basins.

Figure 4.2: Hydropower development in Myanmar



4.2.1 Hydropower Projects by Ownership

The stage of development of 104 dams with a hydropower plant capacity of 10 MW or greater is summarised in Table 4.1 by the number of dams, and in Table 4.2 by installed capacity.

The development stages listed commence with existing and under construction projects, then projects under development from most to least advanced, covering: (i) existing, (ii) under construction, (iii) covenant,[22] (iv) Projects planned by GOM awaiting funding, (v) JVA/BOT for foreign companies; (vi) MoA, (vii) MoU for local companies, (viii) MoU for foreign companies, and (ix) projects with no agreement. The projects are also listed by owner/developer and by basin.

Table 4.1: Number of existing hydropower plants and planned projects by Owner/Development and Development Stage (>10MW)

Stage	Domestic				Foreign JV/BOT	Sum
	MoEE	MoEE/MOALI	MOALI	BOT		
Existing	12	7	3	4	3	**29**
Construction	3	-	1	1	1	**6**
Covenant	-	-	-	1	-	**1**
GOM Plan	-	-	2	-	-	**2**
JVA (1)	-	-	-	-	6	**6**
MoA	-	-	-	-	13	**13**
MoU Local				5		**5**
MoU	-	-	-	-	22	**22**
No Agreement (2)	-	-	-	-	2	**2**
Sum	**15**	**7**	**6**	**11**	**47**	**86**
Unassigned projects at identification stage						18
					Total	**104**

Notes: (1) Six JVAs have been signed, but one, Myitsone HP project, has been suspended; (2) Tamanthi (Chindwin Basin) and Taninthayi have been suspended.

Table 4.2: Hydropower Installed Capacity (MW) by Owner/Developer and Development Stage (>10 MW)

Stage	Domestic				Foreign JV/BOT	Sum
	MoEE	MoEE/MOALI	MOALI	BOT		
Existing	1,474	492(1)	144(2)	249(3)	939	**3,298**
Construction	442	-	42	30	1,050	**1,564**
Covenant	-	-	-	20	-	**20**
GOM Plan	-	-	214	-	-	**214**
JVA	-	-	-	-	13,160	**13,160**
MoA	-	-	-	-	16,030	**16,030**
MoU Local	-	-	-	606	-	**606**
MoU	-	-	-	-	11,024	**11,024**
No Agreement	-	-		-	1,800	**1,800**
Sum	**1,916**	**492**	**400**	**905**	**44,003**	**47,716**
Unassigned projects at identification stage						994
					Total	**48,710**

Notes: (1) includes: Ka Baung, Mone Chaung, Lower Paung Laung, Phyu Chaung, Thapenzeik, Yenwe, Zawgyi II; (2) includes: Kyee Ohn Kyee Wa, Myittha, Myogyi; (3) includes: Mali, Mongwa, Baluchaung 3 and Thauk Ye Khat (2).

There are 29 existing hydropower plants in Myanmar with a total installed capacity of 3,298 MW, and six power plants under construction with a total installed capacity of 1,564 MW. The remaining 51

[22] Covenant is the domestic equivalent of JVA for foreign supported projects

projects with total installed capacity of 42,968 MW are in various stages of pre-construction development.[23] These tables and the HPP database include some large projects that have been suspended.

The tables show that, save for two projects proposed to be developed by MoAIL totalling 214 MW, the yet to be committed hydropower projects would be developed by the private sector: six projects totalling 596 MW by Myanmar developers and 43 projects totalling 42,158 MW by foreign developers in JV with MoEE. The 58 proposed project private sector development would represent 94% of all hydropower capacity installed.

4.2.2 Hydropower Projects by Basin

The Ayeyarwady Basin (including Chindwin) has 14 hydropower plants in operation, with three projects under construction and 32 planned (Table 4.3). The Thanlwin Basin follows with four power plants in operation, two under construction and 15 planned. The third basin with a significant number of power plants is the Sittaung with nine in operation and three planned.

Table 4.3: Number of existing Hydropower Plants and Planned Projects by Basin and Development Stage (>10 MW)

	Ayeyarwady (*)	Thanlwin	Sittaung	Mekong	Rakhine	Tanintharyi	Bago	Bilin	Sum
Existing	14	4	9	1	-	-	1	-	29
Construction	3	2	-	-	1	-	-	-	6
Covenant	1	-	-	-	-	-	-	-	1
GOM Plan	2	-	-	-	-	-	-	-	2
JVA	5	1	-	-	-	-	-	-	6
MoA	9	4	-	-	-	-	-	-	13
MoU Local	1	-	1	2	-	-	-	1	5
MoU	8	7	1	4	2	-	-	-	22
No Agreement	6	3	1	1	4	5	-	-	20
Sum	**49**	**21**	**12**	**8**	**7**	**5**	**1**	**1**	**104**

(*) Includes Chindwin

The Ayeyarwady has the highest installed capacity in operation (2,100 MW). If all proposed hydropower projects are built, the Ayeyarwady and Thanlwin would have around 28,100 MW (58% of all hydropower) and 16,500 MW (34%) respectively (Table 4.4). The development of all proposed hydropower projects in the other basins (8%) would represent a much lower total installed capacities ranging from 20 MW to 1,070 MW.

[23] It should be noted that this figure might change as feasibility studies are completed and designs finalized.

Table 4.4: Existing and Planned Hydropower Installed Capacity (MW) by River Basin and Development Stage (>10 MW)

	Ayeyarwady (*)	Thanlwin	Sittaung	Mekong	Rakhine	Tanintharyi	Bago	Bilin	Sum
Existing	2,100	302	810	66	-	-	20	-	**3,298**
Construction	1,372	81	-	-	111	-	-	-	**1,564**
Covenant	20	-	-	-	-	-	-	-	**20**
GOM Plan	214	-	-	-	-	-	-	-	**214**
JVA	11,760	1,400	-	-	-	-	-	-	**13,160**
MoA	9,245	6,785	-	-	-	-	-	-	**16,030**
MoU Local	100	-	160	66	-	-	-	**280**	**606**
MoU	1,821	7,795	100	618	690	-	-	-	**11,024**
No Agreement	1,445	130	150	30	344	696	-	-	**2,794**
Sum	**28,077**	**16,493**	**1,220**	**780**	**1,145**	**696**	**20**	**280**	**48,710**

(*) Includes Chindwin

Seven countries are involved in hydropower development in Myanmar: PRC (34 projects totalling 34,976 MW), Singapore (6 projects - 685 MW), France (3 projects - 1,740 MW), Thailand (3 projects - 4,780 MW), Austria (1 project - 66 MW), India (1 project - 1,200 MW), and Norway (1 project - 700 MW).[24] Eighteen of the projects being developed by PRC companies are in Kachin State (21,403 MW) and 11 in Shan State (12,303 MW).

[24] Totals exceed the values in the above tables because companies from different countries are working on the same project.

5 HYDROPOWER PROJECTS

This section describes (i) existing and under construction HPPs and (ii) planned HPPs[25] in eight basins in Myanmar:

- Ayeyarwady-Chindwin
- Thanlwin
- Sittaung
- Mekong
- Bago
- Rakhine
- Tanintharyi
- Bilin

5.1 Ayeyarwady Basin

The 2,170 km long Ayeyarwady River has a catchment area of 413,710 square kilometers (km^2), and is divided into five hydro-ecological zones for analysis (Figure 5.1):

1. **Ayeyarwady Headwaters** - from its source in the mountains bordering PRC to the confluence of the Mali Hka and the N'Mai Hka at Myitsone in Myitkyina District. Its drainage area is 47,557 km^2 (11.5% of the total Ayeyarwady basin drainage area).
2. **Middle Ayeyarwady** - from Myitsone to the confluence of the Chindwin River. Its drainage area in Myanmar is 132,195 km^2 (the remaining 11% is in PRC). The Middle Ayeyarwady including the area in PRC represents 32% of the total Ayeyarwady basin drainage area)
3. **Chindwin** - a major tributary of the Ayeyarwady River. It is in Myanmar considered as a main river basin, but in the context of this analysis, we have taken it to be a tributary feeding its development environmental impacts into the Ayeyarwady. Its drainage area is 114,687 km^2 (28% of the total Ayeyarwady basin drainage area)
4. **Lower Ayeyarwady** from the Chindwin River confluence to the delta at a small village called Ngapiseik;
5. **Delta:** The delta starts about 93 km upstream of Hinthada, the tidal influence expands to the town of Myan Aung. The Delta covers an area of around 31,000 km^2 with a coastal front of 260 km.

As there are no existing hydropower plants or planned projects in the Delta area, the analysis in this hydropower chapter only include the Headwaters, Middle and Lower Ayeyarwady and Chindwin.

[25] The text provides estimated dates for project completion provided by MoEE. These dates are based on earlier power development plans and many are no longer achievable. JICA is providing assistance to MoEE to prepare an update of the power development plan that will select hydropower projects from MoEE's master list. MoEE is using the Wien Automatic System Planning (WASP) software maintained by the International Atomic Energy Agency (IAEA) that will result in new dates for project completion up to 2030. Not all the projects listed in this report are expected to go ahead by 2030. Preliminary WASP runs indicate that about 30 - 35 of the planned projects in this report would be included in the next Power System Development Plan.

Figure 5.1: Hydropower development in the Ayeyarwady Basin

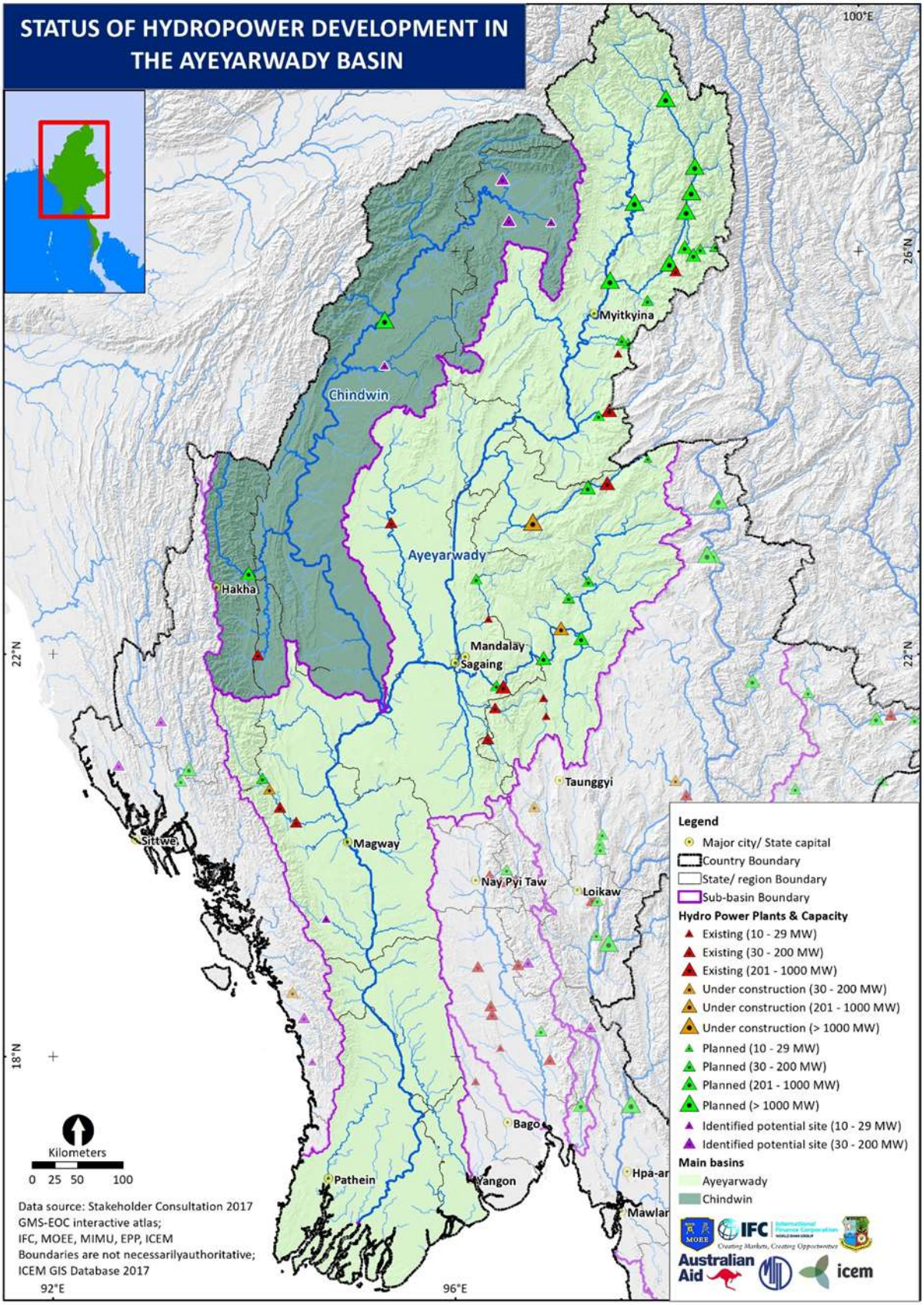


Table 5.1-Table 5.2-Table 5.3 provide a summary of the hydropower development in the Ayeyarwady basin. The sections below provide a summary of the projects and their main characteristics in the hydro-ecological zones (excluding the Delta) and sub-basins.

Table 5.1: Hydropower Development (>10 MW) in the Ayeyarwady Basin

Development Status	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Existing and under construction	17	3,472	>14,987	1 - 150	>16,521	>846	>356
Planned	32	24,605	>136,456	27-223	>57,883	>1,406	>814
Sum	**49**	**28,077**	**>151,443**	**1-223**	**>74,354**	**>2,252**	**>1,170**

Note: ">" = "more than"

Table 5.2: Existing and Under Construction Hydropower Plants (>10 MW) in the Ayeyarwady Sub-Basins

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Ayeyarwady Headwaters	**1**	99	NP	48	**1.2**	**0.07**	**0.7**
Chipwi Hka	1	99	NP	48	1.2	0.07	0.7
Middle Ayeyarwady	**12**	**3,142**	**14,117**		**>14,583**	**>733.2**	**306**
Mali	1	11	54	NP	NP	NP	NP
Dapein	1	240	1,065	46	22	0.4	4
Shweli	2	1,650	7,422	47 - 150	5,451	119.1	76
Ma Gyi Chaung	1	25	134	57	448	40.5	16
Myitnge/Zawgyi	6	1,186	5,325	1 - 132	5,110	175.7	167
Mu	1	30	117	33	3,553	397.1	43
Chindwin	1	40	170		325	12.20	NP
Myittha	1	40	170	63	325	12.20	NP
Lower Ayeyarwady	**3**	191	700		**1,612**	**113**	**49**
Mone Chaung	3	191	700	42 - 138	1,612	113	49
Ayeyarwady Total	**17**	**3,472**	**>14,987**	**1 - 150**	**>16,521**	**>846**	**>356**

Note: NP = Data not provided; ">" = "more than"

Table 5.3: Planned Hydropower Projects (>10 MW) in the Ayeyarwady Sub-Basin

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Ayeyarwady Headwaters	**13**	**20,495**	**118,853**	**44-223**	**32,33,393**	**>756**	**645**
N'Mai	5	11,100	66,540	141-223	7,334	84	263
Naw Chang Hka	4	1,200	5,459	42-79	77	30	21
Namli	2	295	844	44-81	36	NP	6
Mali	1	1,900	14,720	196	12,756	245	115
Myitsone	1	6,000	31,290	140	13,190	397	100+140
Middle Ayeyarwady	**11**	**2,146**	**>8,859**	**27-92**	**>1,240**	**>65**	**>124**
Nam Tamhpak	2	285	1,319	27-56	>14	>2	~2
Dapein	1	140	642	59	55	NP	8
Shweli	2	540	2,897	54-92	124	>28	>21
Ma Gyi Chaung	1	64	NP	77	593	24	NP
Myitnge	5	1,117	>4,001	27-160	>454	>11	>93
Chindwin	**6**	**1,807**	**>8,588**	**242**	**22,565**	**>509**	**>45**
Chindwin	6	1,807	8,210	242	22,479	>509	>45
Lower Ayeyarwady	**2**	168	>534	-	**>721**	**>76**	**NP**
Mone Chaung	1	150	534	NP	721	76	NP
Mindon	1	18	NP	NP	NP	NP	NP
Ayeyarwady Total	**32**	**24,605**	**>136,456**	**27-223**	**>57,833**	**>1,406**	**>814**

Note: NP = Data not provided; ">" = "more than"

5.2 Ayeyarwady Headwaters

The Ayeyarwady Headwaters have a catchment area of 47,557 km^2, and consist of five rivers and tributaries in three sub-basins where one hydropower plant has been built and 13 are proposed for development (Table 5.4)

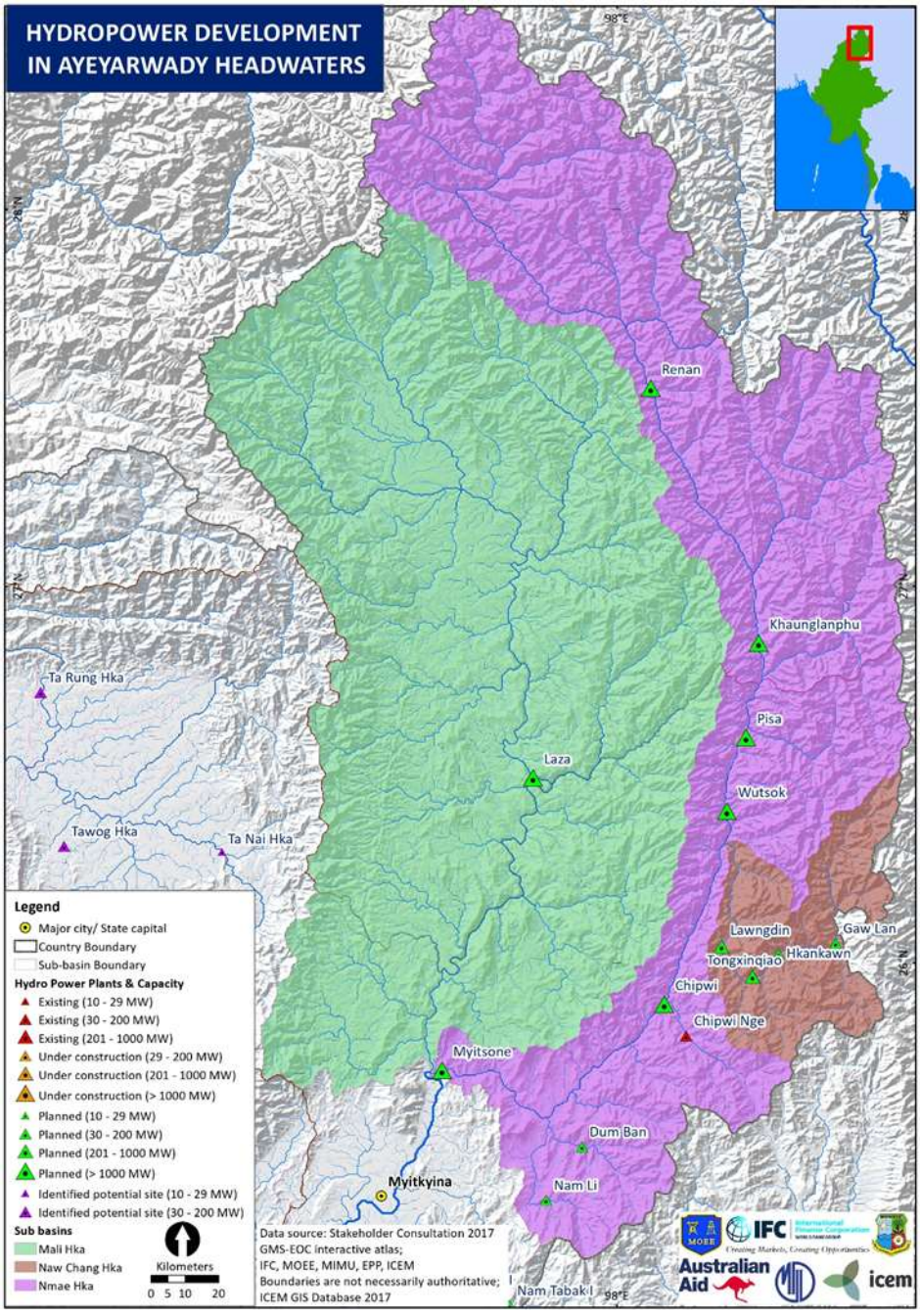
The Ayeyarwady is formed by the confluence of the N'Mai and Mali rivers at Myitsone. These two rivers both flow from glaciers in high mountains along the border with the PRC in northern Myanmar. The N'Mai Hka, the eastern branch, rises in the Languela glacier on the border with Tibet, PRC, and has the greater volume of water,[26] but is virtually unnavigable because of its steepness and many rapids.[27] About 19% of the upper N'Mai Basin where the river rises is in PRC. The Mali River, the western branch all within Myanmar, has a gentler gradient[28] and, although interrupted by rapids, has some navigable sections.

[26] SPIC has established several hydrologic gauging stations in the Mali Hka and the N'Mai Hka and estimated that the average unit flow is around 100 $l/s/km^2$.
[27] Between the Renam and Chipwi dam sites the N'Mai Hka drops about 615 m over a distance of 200 km, resulting in a gradient of 3.1 m/km. As it flows a further 100 km towards the Myitsone dam site, the river is less steep dropping 0.94 m/km or about 94 m.
[28] The river drops about 0.75 m/km, or about 130 m, between the uppermost reach of the Laza reservoir and the Myitsone dam site, a distance of about 170 km.

Table 5.4: Catchment areas of main river sections and tributaries with hydropower potential of the Ayeyarwady Headwaters Sub-basin

River	Tributary	Catchment Area (km^2)[29]	% of sub-basin
N'Mai (at Myitsone)		24,337	51%
	Naw Chang Hka	2,554	10.5%
	Chipwi Hka	712	2.9%
	Namli Hka	1,310	5.4%
Mali (at Myitsone)		23,220	49%

Figure 5.2: Ayeyarwady Headwaters hydropower potential



[29] Catchment areas as provided in HydroSHEDS

5.2.1 Existing and under Construction Hydropower Plants

Chipwi Nge: Only one hydropower facility has been built in the Ayeyarwady Headwaters, the 99 MW Chipwi Nge HPP in 2013, located in Myitkyina District, Kachin State on the Chipwi Hka, a tributary to the N'Mai Hka. This power plant has a 48 m high concrete gravity dam and a small reservoir inundating 0.07 km^2 that stores 0.3 million cubic meters (hm^3) of water. The dam on the Chipwi Hka serves as an intake to a headrace tunnel about 10 km long that leads the water to the powerhouse on the left bank of the N'Mai Hka about 9 km downstream of the confluence between the N'Mai Hka and the Chipwi Hka gaining a head of 433 m. According to the website[30] for the Upstream Ayeyarwady Confluence Basin Hydropower Co. (UACBH) the power plant was built to provide power for the construction of the Myitsone and Chipwi hydropower projects.[31] The power plant now provides power to Chipwi village and Myitkyina through a 132 kV transmission line, but due to low demand, only a fraction of its capacity is being used.

5.2.2 Planned Hydropower Projects

The China Power Investment Corporation (SPIC),[32] formerly China Power Investment Corporation (CPI), has proposed five projects totalling 12,700 MW in the N'Mai River: the 1,400 MW **Renam** HPP, the 3,000 MW **Khaunglanphu** HPP, the 2,400 MW **Pisa** HPP (also known as **Hpizaw**), the 2,500 MW **Wutsok** HPP, all in Puta-O District, Kachin State, and the 3,400 MW **Chipwi** HPP, upstream of Chipwi town (Table 5.5).

Table 5.5: N'Mai River - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Renam	1,200	7,330	159	1,183	9.2	56	6	S	NP
Khaunglanphu	2,700	14,730	223	3,101	32.9	~85	12	S	NP
Pisa	2,000	12,870	153	535	7.9	~31	NP	NP	NP
Wutsok	1,800	13,410	141	605	6.3	29	1	ROR	NP
Chipwi	3,400	18,200	206	1,910	27.7	62	2	ROR	50%
	11,100	**66,540**	**141 - 223**	**7,334**	**84.0**	**~263**			

Source: MoEE/SPIC
Notes: (#) ROR: Run-of-River, S: Storage; (NP) data not provided

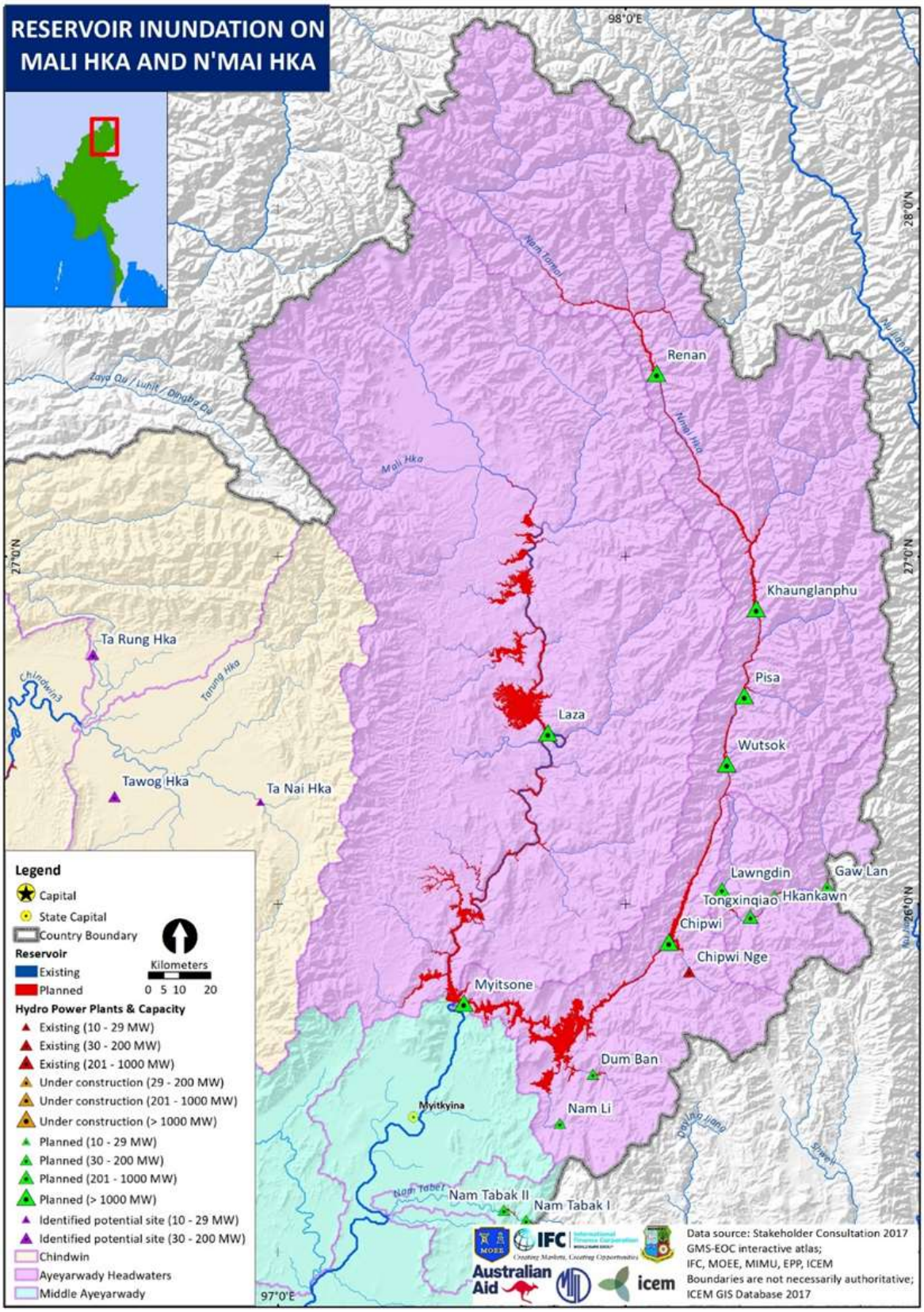
Concrete-faced rock fill dams (CFRD)[33] are being considered for these sites and power plants will be at or close to the dams.

One 100 km long arm of the Myitsone reservoir on the NMai Hka would reach the tailwater of the Chipwi powerhouse. If all projects were to be built, the N'Mai Hka would be continuously inundated for about 363 km. The total inundated area upstream of Chipwi dam would amount to 84 km^2. Dam heights vary between 141 m and 223 m with the potential to store about 7,334 hm^3. The very large depths of these reservoirs could cause significant water quality issues.

Figure 5.3 shows an indicative extent of the inundation in the Mali and N'Mai rivers developed from GIS digital elevation model. A river profile provided by SPIC shows that starting at Myitsone and moving upstream each reservoir would reach the tailwater of the upstream hydropower plant.

[30] http://www.uachc.com/Liems/esiten/detail/detail.jsp?newsNo=11794
[31] http://www.chinadaily.com.cn/m/gezhouba/2014-12/23/content_19144348.htm
[32] SPIC was formed in 2015 when CPI and China State Nuclear Power Technology Corp. merged. (http://eng.spic.com.cn/AboutUs/cp/)
[33] Shuibuya dam in PRC is the highest CFRD dam at 233 m.
(http://www.waterpowermagazine.com/features/featuresharing-international-experiences-in-cfrds/featuresharing-international-experiences-in-cfrds-1.html)

Figure 5.3: Indicative Mali and N'Mai reservoir inundation



MoEE and SPIC signed the MoA for Renam, Khaunglanphu and Pisa on 16 June 2009. They are all scheduled for completion in 2030 (in 13 years). No information is available on the transmission system to evacuate the power. It is also not clear what percentage of the power would be exported. The completion year for the proposed projects, except Chipwi HPP, is ach.

Table 5.6: N'Mai River - Planned Projects - Development Process

HPP	Date submitted EIA (1)	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Year
Renam	-	MoA	16/06/09	SPIC	-	PRC	2030
Khaunglanphu	-	MoA	16/06/09	SPIC	-	PRC	2030
Pisa	-	MoA	16/06/09	SPIC	-	PRC	2030
Wutsok	-	MoA	(2)	SPIC	-	PRC	2030
Chipwi	-	JVA	3/06/10	SPIC	-	PRC	2020

Notes: (1) The date for submission of EIA has not been provided; (2) The MoU was signed on 28 December 2006.

Renam: The 1,200 MW Renam HPP is the upstream-most project in the cascade. It would be built on the N'Mai Hka. Its 159 m high dam would create a reservoir storing 1,183 hm^3 and inundating 9.2 km^2 resulting in a 56 km long reservoir.

Khaunglanphu: The 2,700 MW Khaunglanphu HPP is the next project downstream on the N'Mai Hka. Its 223 m high dam would create a reservoir storing 3,101 hm^3 and inundating 33 km^2 over a distance of 85 km along the N'Mai Hka. The reservoir would reach close to the Renam powerhouse tailrace.

Pisa: The next downstream project would be the 2,000 MW Pisa HPP (also known as Hpizaw). Its 153 m high dam would create a reservoir storing 535 hm^3 and inundating 7.9 km^2 over a distance of 31 km. The reservoir would reach close to the tailrace of the Khaunglanphu HPP.

Wutsok: The 1,800 MW Wutsok would be the next downstream project. Its 141 m high dam would create a reservoir storing 605 hm^3 and inundating 6.3 km^2 over a distance of 28 km. The reservoir would reach close to the tailrace of the Pisa HPP.

Chipwi: The 3,400 MW Chipwi would be the last project before reaching the Myitsone reservoir. Its 206 m high dam would create a reservoir storing 1,910 hm^3 and inundating 28 km^2 over a distance of 56 km. MoEE and SPIC signed the JVA on 3 June 2010 for the Chipwi hydropower project, but there is no information available as to whether an EIA has been submitted for approval. The website[34] of UACBH[35] states that preparatory works for the project began in December 2010. These works included infrastructure to support the hydropower station, such as roads, water supply, electricity (Chipwi Nge HPP), telecommunications as well as land levelling. Work was suspended due to a local conflict situation in the area, including opposition to the dam. The Chipwi hydropower plant was due to be completed by 2020, but this is unlikely now. Chipwi is the last project in the N'Mai cascade before joining the Mali River at the Myitsone site.

5.2.3 Naw Chang River

The Naw Chang, an eastern tributary to the N'Mai, joins it downstream of Wutsok.[36] This is a very steep river dropping about 1,130 m over a distance of 90 km (12.5 m/km on average) between Gaw Lan dam site and confluence with N'Mai Hka; flows are lower than in the N'Mai Hka at around 75 $l/s/km^2$.

[34] http://www.uachc.com/Liems/esiten/list/desc.jsp?newsType=2359&currentPageNo=1

[35] According to the web site, the company is a Sino-Myanmar joint venture registered as a company in Nay Pyi Taw in 2010 to bring together government and private sector expertise so that it could share technical know-how, access to investment, breadth of experience and commitment to socially responsible development. The ownership structure of UACBH comprises: Myanmar's MoEE owns 15%, Asia World Company (AWC) owns 5%, and SPIC (originally CPI Yunnan International Power Investment Company Ltd) has the remaining 80% shareholding. After fifty years of operation UACBH will become 100% Myanmar-owned.

[36] The Wutsok project had originally been located on the Naw Chang Hka in the information provided to the SEA Team, but the elevation data did not support this. SPIC confirmed that it is located on the N'Mai Hka.

The Chinese developer Yunnan Energy Investment Group (YEIG) working with IGOEC (Myanmar) have proposed four run-of-river projects totalling 1,200 MW on this river.[37]

Table 5.7: Naw Chang - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type	Export (%)
Gaw Lan	120	594	47	2	6.7	3	0	ROR	NP
Hkankawn	140	769	42	3	2.0	3	0	ROR	NP
Tongxingqiao	340	1,695	63	5	8.8	4	0	ROR	NP
Lawngdin	600	2,401	79	67	12.4	11	3	ROR	NP
	1,200	**5,459**		**77**	**29.9**	**21**			

Table 5.8: Naw Chang - Planned Projects - Development Process

HPP	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Year
Gaw Lan	13/11/14	JVA	9/03/16	YEIG	IGOEC	PRC	2026
Hkankawn	13/11/14	MoA	23/07/10	YEIG	IGOEC	PRC	2026
Tongxinqiao	18/03/11	JVA	19/02/16	YEIG	IGOEC	PRC	2026
Lawngdin	13/11/14	MoA	23/07/10	YEIG	IGOEC	PRC	2026

Gaw Lan: The 120 MW Gaw Lan is a run-of-river project with a 47 m high concrete gravity dam creating a relatively small reservoir inundating 6.7 km^2 and small storage of 2 hm^3. The project is has a run-of-river with diversion layout. The powerhouse is about 11 km downstream of the intake dam creating a head on the turbines of 175 m. The power plant would be connected to Hawkawn s/s by a 15 km long double-circuit 230 kV transmission line.

Hkankawn: The 140 MW Hkankawn is also a run-of-river project, its 42 m high concrete gravity dams creating a relatively small reservoir inundating 2 km^2 and storing about 3 hm^3. The project has also a run-of-river with diversion layout. Accurate coordinates for the dam and powerhouse were not provided, but the gross head on the turbine is about 130 m, which is higher than the dam, indicating that this is a diversion project and turbines are therefore not at the foot of the dam. The power plant would be connected to Tongxingqiao s/s by a 15 km long double-circuit 230 kV transmission line.

Tongxingqiao: The next project downstream is the 340 MW Tongxingqiao HPP[38] with a 63 m high concrete gravity dam and a diversion configuration. It has been estimated using GE and information on FSL and head on the turbine of 260 m that the powerhouse is about 13 km downstream. The power from this plant, Gaw Lan HPP, Hkankawn HPP and Lawngdin HPP would be transmitted from the

[37] Earlier studies had identified the 60 MW Wu Zhongza in this sub-basin, but has now been excluded from MoEE's master list

[38] The coordinates provided to the SEA Consultants for this project do not seem to be correct as they locate it downstream of the Lawngdin hydropower project. The river elevation at this location is around el.630 m. The Tongxingqiao FSL is at el.1,075 m and the catchment area provided for the project is smaller than that of the Lawngdin project. This indicates that Tongxingqiao should be upstream of Lawngdin. Therefore we have adjusted the coordinates based on the FSL and dam height. The powerhouse has also been located at some distance downstream from the dam based on information on design head.

substation at this power plant to Waimaw s/s close to Myitkyina by a 130 km long double-circuit 500 kV transmission line.[39]

Lawngdin: The 600 MW Lawngdin with a 79 m high dam is the last project in the cascade.[40] The power plant would be connected to Tongxingqiao s/s by a 116 km long[41] double-circuit 230 kV transmission line.

The most advanced in the development process are the Gaw Lan and Tongxinqiao with JVAs signed in March and February 2016 respectively. The planned commissioning year of 2026 is achievable.

5.2.4 Namli River

The Namli joins the N'Mai River from the south (left hand bank) about 50 km downstream of the proposed Chipwi hydropower plant and into the proposed Myitsone reservoir area. The projects are in two separate tributaries. Availability of flows is lower than in more northern basins and estimated at around 60 l/s/km^2.

Table 5.9: Nam Li/Dum Ban - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Nam Li	165	473	44	2	NP	1	1	ROR	0%
Dum Ban	130	371	81	34	NP	5	9	S	0%
	295	**844**		**36**	**NP**	**6**			**0%**

(#): ROR: Run-of-River, S: Storage

Table 5.10: Nam Li/Dum Ban - Planned Projects - Development Process

HPP	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Year
Nam Li	n.a.	MoU	24/10/14	YPEP	Chan Yinn Khuu	PRC	2020
Dum Ban	n.a.	MoU	11/2/15	YPEP	Chan Yinn Khuu	PRC	2020

Nam Li: the proposed 94 MW Nam Li HPP on the Namli Hka close to Hkritu village will have a 44 m high concrete gravity dam with a FSL at el. 590 m m.s.l.[42] The head on the turbines is 322 m placing the powerhouse at around EL250 m,[43] about 3.4 km downstream according to the data provided by MoEE.

Dum Ban: The proposed 75 MW Dum Ban HPP on the Tampang Hka, a tributary to the Namli Hka, will have an 81 m high concrete gravity dam with FSL at el.405 m and a tunnel 4.6 km long. It should

[39] Need confirmation whether this transmission line would be connected to the Myitsone transmission system for export to PRC.

[40] Very little information was provided for this project.

[41] This distance provided by MoEE needs checking – distance from Gaw Lan dam, the upstream most dam, to the confluence with the N'Mai is about 90 km. The Tongxingqiao is about half way to the confluence and Lawngdin is downstream of Tongxingqiao. A distance between them of 116 km seems excessive.

[42] MoEE has reported the reservoir to have a surface area of 340 km^2 at FSL405 m. This seems too high.

[43] The Myitsone FSL is at 245 m.

be noted however, that if the tailwater elevation were correct (TWL218m), then the powerhouse would be drowned by the proposed Myitsone reservoir.

YPEP/Chan Yinn Khuu is developing both projects, which are at the feasibility/EIA stage since the MoA has not yet been signed. The completion in 2020 is not achievable.

5.2.5 Mali Hka

There is only one proposed hydropower project on the Mali Hka, Laza HPP.

Table 5.11: Mali River - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Reservoir Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Laza	1,900	14,720	196	12,756	245	115	35	S	50%

(#): ROR: Run-of-River, S: Storage

Table 5.12: Mali River - Planned Projects - Development Process

HPP	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Year
Laza	-	JVA	3/06/10	SPIC	-	PRC	2025

Laza: According to UACBH the 1,900 MW Laza HPP on the Mali River would be the next hydropower project to be developed by SPIC in the sub-basin after Myitsone because of its ease of access.[44] The projects on the N'Mai Hka cascade are more difficult to access due to the steep and difficult terrain. The Laza dam height was limited to 196 m so not inundate Machanpow Town close to Putao City. The CFRD dam would nevertheless create a reservoir 115 km long[45] inundating 245 km^2 and storing 12,756 hm^3, a volume almost as large as the Myitsone reservoir.

MoEE and SPIC signed the JVA on 3 June 2010, on the same date as for Khaunglanphu and Chipwi. Fifty percent of the power is to be exported to PRC. Laza is proposed to be completed by 2025, but this seems unrealistic now if it were to go ahead.

5.2.6 Mainstream Ayeyarwady

Table 5.13: Mainstream Ayeyarwady - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km) (*)	Retention Period (days)	Type (#)	Export (%)
Myitsone	6,000	31,290	140	13,190	396.7	140 +100	10	S	90%

(*) The reservoir has two branches: the one extending up the Mali Hka is 140 km long and reaches up to the tailwater of the Laza hydropower plant; the one extending up the N'Mai Hka is 100 km long and reaches up to the Chipwi power plant tailwater. The FSL of Myitsone was limited by the elevation of Chipwi Town. (#): S: Storage

[44] http://www.mmtimes.com/index.php/business/8074-ayeyarwady-hydro-dams-in-limbo.html

[45] The gradient of the river over the 115 km long reservoir is 1.1m/km.

Table 5.14: Mainstream Ayeyarwady - Planned Projects - Development Process

HPP	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Myitsone	1/06/11	JVA Started construction	20/02/10	SPIC	AWC	PRC	Suspended in 2011

Myitsone: The 6,000 MW Myitsone hydropower project planned at the confluence of the Mali Hka and the N'Mai Hka has been suspended since 2011. Its proposed 140 m high dam would create a large reservoir inundating 397 km^2 and storing 13,190 hm^3. Generation at this site would benefit from the large upstream storage projects proposed by SPIC. Ten percent of generation would be provided to Myanmar free (about 2,940 GWh or 27% of consumption in 2014). Although 90% is earmarked for export, Myanmar would have an option to purchase additional power from the project. Also, according to the UACBH website, water flows in the Ayeyarwady River downstream of the dam would increase 16% in the dry season and reduce by 3.5% during the flooding season. MoEE and SPIC/UACBH signed the JVA on 20 February 2010 and started construction of preliminary works. The EIA however was submitted to MONREC on 1 June 2011.[46] Figure 5.4 shows the confluence of the N'Mai and Mali rivers upstream of the Myitsone dam site.

Figure 5.4: Confluence between N'Mai and Mali forming the Ayeyarwady

The N'Mai flows into the confluence from the right, and the Mali from the left hand side of the picture

5.2.7 Summary

Developing all the proposed projects could have severe impact on the basin given that about 645 km of rivers would be inundated with a total estimated surface area of about 760 km^2, an area about the same as the city of Singapore. The total storage would amount to 33,393 hm^3, of which 19,235 hm^3 would be dead storage. Potentially, 44 km of rivers would be dry during part of the year unless effective environmental flow arrangements were implemented.

[46] MoU was signed on 28 December 2006; the feasibility submitted to MoEE on 28 November 2009, and MoA signed on 16 June 2009.

Of the 13 projects proposed for the Ayeyarwady Headwaters, plus one already operational (Chipwi Nge), SPIC is developing eight with a total installed capacity of 21,500 MW (94% of the proposed total installed capacity in the sub-basin) generating about 113,900 GWh or about 12 times more than hydropower generated in 2013-14 in Myanmar. Except for Chipwi Nge, all the projects proposed by SPIC would be very high concrete-faced rock fill dams (CFRDs) in the range 140 m to 223 m, creating large reservoirs with inundations up to 397 km^2, and total storage up to 32,304 hm^3.

The height of the dams being developed by YEIG, totalling an installed capacity of 1,200 MW, would be in the range 42 m to 79 m,[47] and inundation would be limited to about 30 km^2 - all would be run-of-river.

5.3 Middle Ayeyarwady

The Middle Ayeyarwady sub-basin stretches from the Myitsone dam site southward towards the Chindwin confluence. The overall catchment area of the Middle Ayeyarwady is 148,534 km^2 of which 92% is in Myanmar, the rest (about 12,413 km^2) in PRC. The river drops about 100 m between Myitsone and the confluence with the Chindwin to el.55 m over a distance of about 705 km, giving it a gentle gradient of about 0.14 m/km. About 50 km south of the confluence at Myitsone is the town of Myitkyina, the northernmost limit of seasonal commercial navigation. Bahmo, about 240 km south of the confluence, is the northern limit for year-round navigation.

The following tributaries to the Ayeyarwady have existing hydropower or multipurpose facilities or proposed hydropower projects (listed from north to south):

Table 5.15: Middle Ayeyarwady Sub-basin - Catchment Areas of main river sections and tributaries

River	Tributary	Catchment Area (km^2)	% of sub-basin
Namtabak		1,684	1.1%
Dapein		7,053	4.4%
Shweli		22,908	14.4%
Ma Gyi Chaung		4,341	2.7%
Myitnge		47,023	29.7
	Zawgyi	4,813	10.2
	Panlaung Chaun	2,794	5.9%
Mu		19,750	12.5
Other tributaries		45,771	30.8

There are ten hydropower plants with an installed capacity of 1,812 MW in the sub-basins in the Middle Ayeyarwady. Their dams inundate about 590 km^2 and store about 8,800 hm^3. The cumulative length of the inundation reaches 179 km, and more than 15.5 km have been left dry or partly dry between dam and powerhouse. Two projects under construction on the Shweli and Myitnge would add 1,330 MW and inundate a further 70 km^2 storing 5,769 hm^3, an increase of 12% and 65% respectively. Four of the 12 projects also serve for irrigation. (Table 5.3 and sections below)

In the Middle Ayeyarwady there are 11 proposed hydropower projects with a potential installed capacity of 2,146 MW: two in the Namtabak, one in the Dapein River, two in the Shweli River, one on the Ma Gyi Chaung River, two in the Myitnge River and three in tributaries of the Myitnge River upstream of the Upper Yeywa. (Table 5.1, Table 5.2 and sections below).

[47] Dam height is provided as a proxy to maximum water depth at the dam site. However, one must consider that dam height is normally given as the difference in elevation between top of dam and lowest foundation level. Typically the part of the dam between the natural ground level (or river bottom) and foundation could be 20% of the dam height, although this varies from site to site. The height difference between full supply level (FSL) and top of dam, the also varies depending on dam type and spillway arrangements but could typically vary between 5 m and 10 m. Therefore, assuming the above values, a 50 m high dam could have a water depth at the dam site of say 50 m - 0.2x50 m - 5 m = 35 m.

5.3.1 Mali Creek

5.3.1.1 Existing Hydropower Plants

MoEE did not include any projects in this river. However, an Internet search[48, 49] and inspection of Google Earth imagery based on reports from the field, resulted in two projects being identified in the area: the Mali HPP and the Dabak HPP.

Mali HPP: The 10.5 MW Mali HPP was started in 1997 and completed by Buga Co. in 2006.[50] Its location has been reported to be close to the village Gau Dau Yang. It provides power to Myitkyina and its environs.

Table 5.16: Namtabak - Existing power plants and under construction - Key Data

HPP	Stage	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Year
Mali	E	10.5	53.5	NP	NP	NP	NP	NP	NP	2006

(NP) not available; (#): S: storage, ROR: run of river.

Figure 5.5: Hydropower development in Namtabak Sub-basin

[48] https://www.globalwitness.org/documents/15216/achoiceforchinapart2-37-72.pdf
[49] http://www.burmalibrary.org/docs2/ELEC-Burma-4th-edition.pdf
[50] http://www.wreutgroup.com/wreut.html

5.3.2 Namtabak

The Namtabak rising in Yunnan Province, PRC is the first tributary with an identified hydropower potential. It has a catchment area of 1,684 km^2 and flows from the east into the Middle Ayeyarwady. Four branches of the river in PRC, which cover 1,438 km^2 (85% of the overall basin), are regulated by at least 19 run-of-river and storage dams (Figure 5.5). According to data received from MoEE, there are no hydropower plants with installed capacity exceeding 10 MW in the Myanmar section of this river.

Dabak HPP: The Dabak HPP (24 MW) was reported started while it was assigned to Buga Co in 1997, but possibly with little progress. It has apparently been taken over by China Goudian who has expanded it to two power plants now called Nam Tabak I and Nam Tabak II totalling 285 MW. See Table 5.17.

5.3.2.1 Planned Hydropower Projects

MoEE and China Goudian/Tun Thwin Mining signed the MoU on 20 January 2011 for two projects in cascade with installed capacity of 96 MW and 104 MW;[51] with a MoA following in August 2015 after the feasibility study had been submitted in which the combined installed capacity had been further increased to 285 MW. The investor has not submitted ESIA Report. Projects are due for completion in 2027, but there is no information whether power would be for use in Myanmar, or for export (considering its closeness to an established grid across the border in PRC).

Table 5.17: Namtabak - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Nam Tabak I	141	635	27	14	2.2	1	NP	ROR	NP
Nam Tabak II	144	684	56	NP	NP	1	NP	ROR	NP
	285	**1,319**		**>14**	**>2.2**	**2**			NP

(NP) not available; (#): S: storage, ROR: run of river.

Table 5.18: Namtabak- Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Nam Tabak I+II	-	MoA	31/08/15	China Guodian	Tun Thwin Mining	PRC	2027

Nam Tabak I: The 22 m high concrete gravity dam of the 141 MW Nam Tabak I would be built about 1 km downstream from the border with PRC. Its reservoir would stretch up to the border. The headrace will lead the water to a powerhouse about 6 km downstream.

Nam Tabak II: About 3 km downstream of the Nam Tabak I powerhouse, a second 56 m high concrete gravity dam would serve as intake to the headrace of the 144 MW Nam Tabak II HPP.[52]

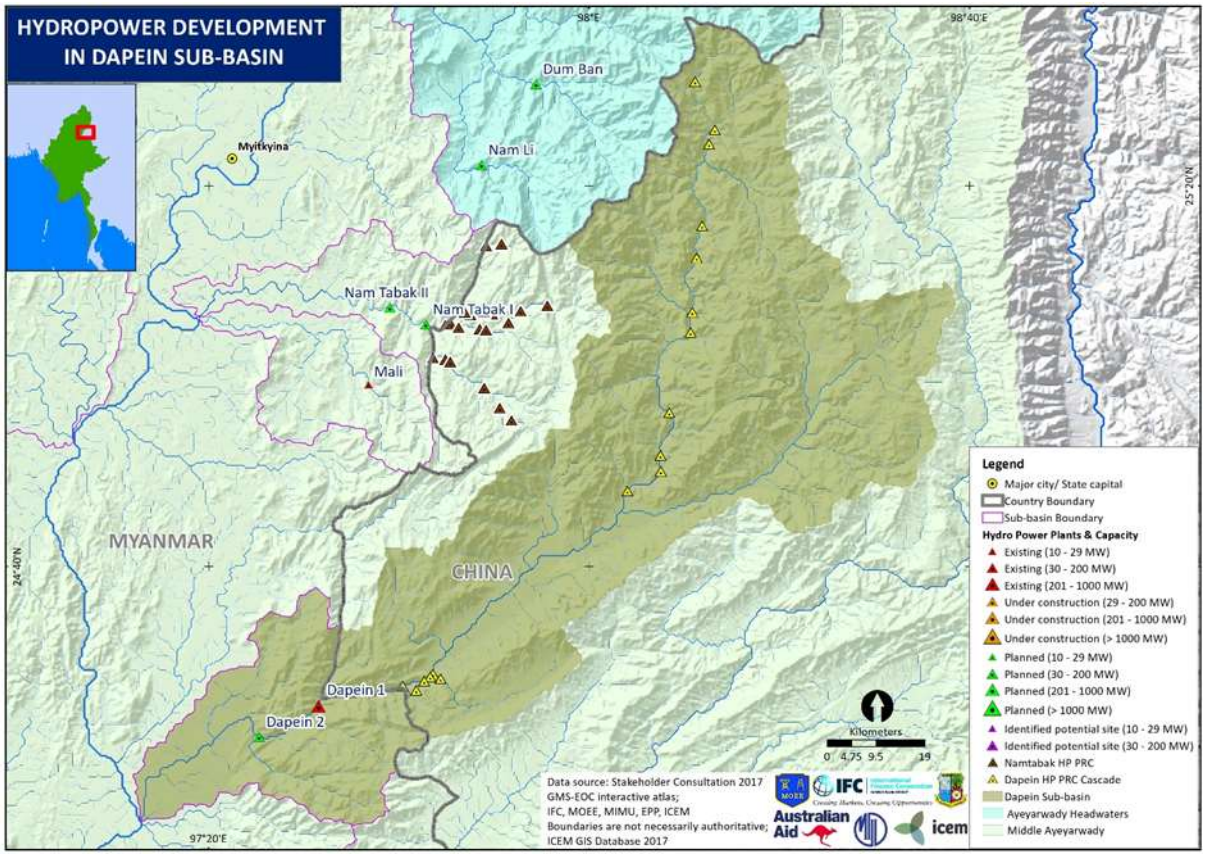
[51] The Nam Tabak HPP had been earlier been assigned to Buga Co. with an installed capacity of 24 MW for one power plant only. It was then known as Tabak.

[52] No coordinates have been provided. The Nam Tabak II configuration is approximate and based on estimations from FSL and dam height.

5.3.3 Dapein Sub-basin

Dapein River, joining the Ayeyarwady at Bahmo from the east with a catchment area of 7,053 km^2, is highly regulated in PRC with more than 18 hydropower run-of-river and storage dams (Figure 5.6). About 14% of the catchment is in PRC. The furthermost downstream power plant in PRC discharges its waters at the PRC-Myanmar border into the Dapein 1 Reservoir at Bahmo District, Kachin State. The identified hydropower potential in the Myanmar area of the sub-basin is 380 MW.

Figure 5.6: Existing and planned hydropower development on the Dapein Sub-basin



5.3.3.1 Existing Hydropower Plants

Table 5.19: Dapein Sub-basin - Hydropower Facility Characteristics

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Dapein 1	E	240	1,065	46	22	0.35	0.4	4.3	China Datang	2011

(*): "E": Existing, "C": under construction

Dapein 1 HPP was completed in 2011 by China Datang Corporation.[53] It has a 46 m high dam and headrace tunnel that diverts water to the powerhouse some 4.3 km downstream. The small, narrow (average 130 m wide) reservoir inundates 0.35 km^2, stores 22 hm^3, and extends 2.6 km up to the

[53] China Datang Corporation (CDT) is a power generation enterprise group established in December 2002 on the basis of the partial power generation assets of former State Power Corporation of China. It is a solely state-owned corporation.

Myanmar-PRC border, immediately below a powerhouse within the PRC. Myanmar takes 19 MW (8%) of the power through a 37 km long 132 kV transmission line to Bamaw (Bahmo) s/s, while 221 MW is exported to PRC via a 500 kV transmission line. The hydropower plant has a similar layout to most of the run of river hydropower plants in the same river in PRC (i.e. intake dam with relatively small reservoir - headrace tunnel - powerhouse).

The Dapein 1 hydropower plant was registered with the UNFCC CDM (Project 7731) on 4 February 2013. The crediting period is valid until 2020 and is renewable.[54]

5.3.3.2 Planned Hydropower Projects

Table 5.20: Dapein Sub-basin - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Dapein 2	140	642	59	55	NP	8	NP	ROR	0%

(NP) not available; (#): S: storage, ROR: run of river

Table 5.21: Dapein Sub-basin - Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Dapein 2	NP	MoU	31/07/08	DUHD	NP	PRC	2022

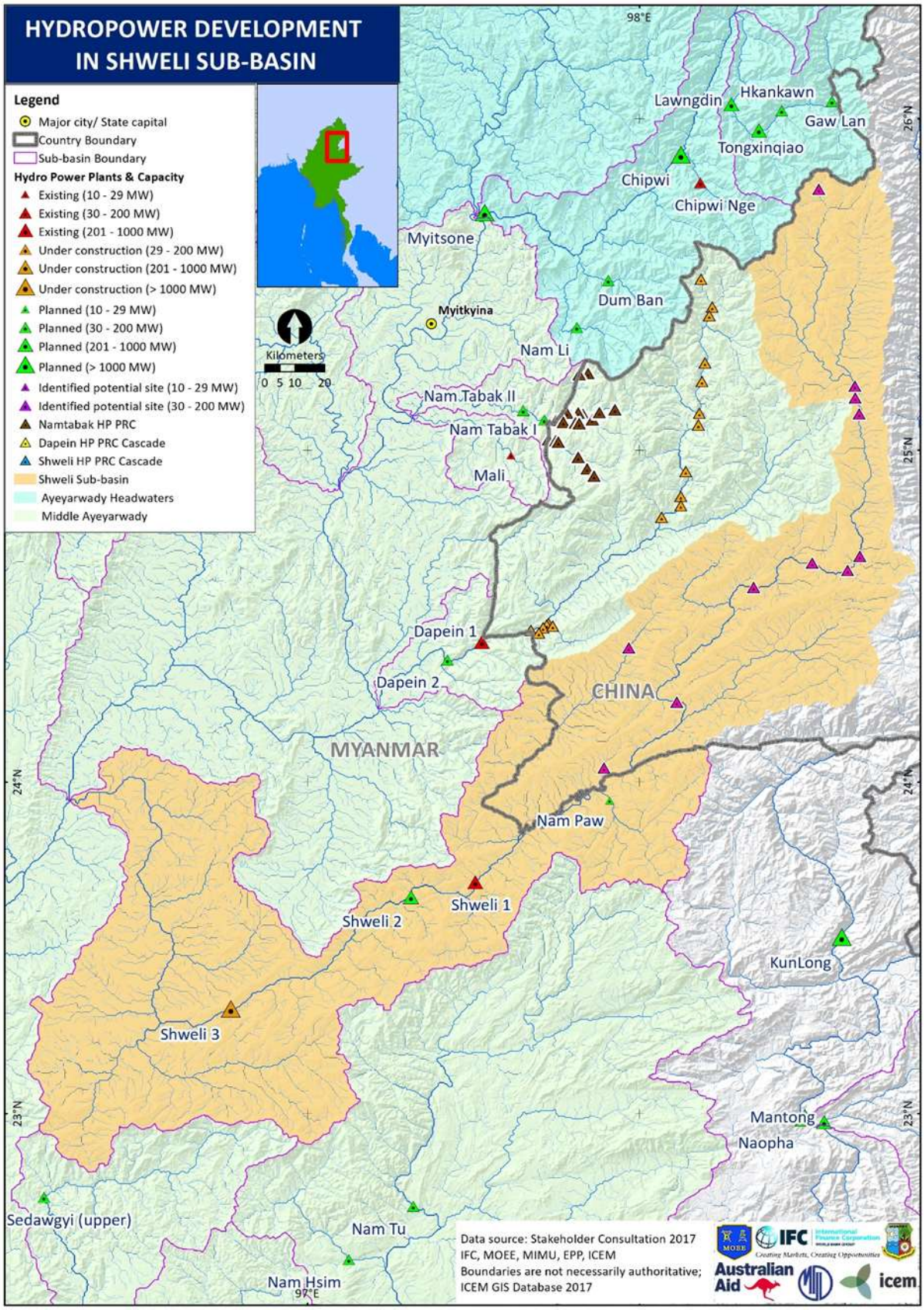
Dapein 2: MoEE and United Hydropower Developing Co. (DUHD), PRC signed a MoU for the Dapein 2 HPP on 31 July 2007. The developer submitted the feasibility study to MoEE in December 2009. Since then, little progress seems to have occurred. The project would consist of a 59 m high concrete gravity dam on the Dapein River about 10 km downstream of the existing Dapein 1 HPP. MoEE did not provide the coordinates for the dam, but from information about FSL and TWL, we have deduced the approximate location of the dam site. The reservoir would be about 8 km long with a relatively small storage of 55 hm^3 given the steepness of the river (gradient of 5.8 m/km). It is planned to be connected to the Dapein 1 s/s by a 16 km long 230 kV transmission line. The power is expected to be used in Myanmar.

5.3.4 Shweli Sub-basin

Next tributary to join the Ayeyarwady from the east is the Shweli River with a catchment area of 22,908 km^2. The Shweli River rises in PRC close to the N'Mai Hka and has in PRC a catchment area of about 9,960 km^2 (43.5%) where it is regulated by more than 11 run of river and storage dams. Flow availability is about 30.5 $l/s/km^2$ at the Myanmar sites, about one third of inflows in the N'Mai Hka. The identified hydropower potential in the Myanmar area of the sub-basin is 2,190 MW.

[54] https://cdm.unfccc.int/Projects/DB/JCI1350363892.83/view

Figure 5.7: Existing and planned hydropower development in the Shweli Sub-basin



5.3.4.1 Existing Hydropower Plants

Table 5.22: Shweli Sub-basin - Hydropower Facility Characteristics

Power Plant	Stage	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Country of Developer	Year
Shweli 1	E	600	4,022	47	24	1.30	10.50	9.5	YUPD, PRC	2009
Shweli 3	C	1,050	3,400	150	5,427	43.44	65.0	NP	EdF, FRA	2020
Sum		**1,650**	**7,422**	**47-150**	**5,451**	**44.74**	**75.5**	**9.5**		

Notes: (NP) = Not provided; (*): "E": Existing, "C": under construction

Shweli 1: The 600 MW Shweli 1 HPP in Muse District, Shan State completed in 2009 about 23 km from the PRC-Myanmar border is the only hydropower plant operating on the river in Myanmar. Of the 600 MW, MoEE informed the SEA team that the 400 MW (67%) is consumed in Myanmar, and 200 MW exported to PRC through a double circuit 220 kV transmission line. The Shweli 1 HPP has a 47 m high concrete gravity dam that diverts water through a headrace tunnel to the powerhouse some 9.5 km downstream. The 10 km long reservoir created by the dam is also small and narrow (about 120 m wide on average) inundating 1.3 km^2 and storing 24 hm^3. It was built and is operated by YUPD[55] of PRC. It has been connected to the Mansan s/s by a 96 km long 230 kV transmission line. Myanmar has bought back some of the power to cover shortages.

Shweli 3: A second power plant is presently under construction about 90 km downstream of Shweli 1 powerhouse, the 1,050 MW Shweli 3 HPP in Kyaukme District, Shan State. The construction diversion tunnel has been completed and the dam area cleared. Construction has stalled for lack of funds. The roller compacted concrete (RCC) dam will be 150 m high, and would create a significantly large reservoir that will inundate 43 km^2 and store 5,427 hm^3. MoEE is negotiating with the French company Electricité du France (EdF) to take over as the developer. The plan is to connect this project to Meikhtila s/s by a 500 kV transmission line.

5.3.4.2 Planned Hydropower Projects

Table 5.23: Shweli Sub-basin - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Shweli 2	520	2,814	92	72	28	20	1	ROR	50%
Nam Paw	20	83	54	52	NP	1.3	Daily	ROR	0%
Sum	**540**	**2,897**	**54-92**	**124**	**>28**	**21.3**			

(NP) not provided; (#): S: storage, ROR: run of river

[55] Yunnan joint Power Development Co (YUPD) established in August 2006 by Yunnan Huaneng Lancang River Hydropower Development Co. and Yunnan Power Grid Co.

Table 5.24: Shweli Sub-basin - Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Shweli 2	23/11/13	MoA	24/11/10	HIE	AWC	PRC	2021
Nam Paw	-	Covenant	16/3/16	-	Great Hor Kham	-	2019

Shweli 2: The 92 m high CFRD of the 520 MW Shweli 2 HPP is being proposed about 19 km downstream of the Shweli 1 powerhouse. YUPD with Asia World Company (AWC, Myanmar) are developing the project and it is intended that 50% of the power would be exported to PRC. The company signed the MoA with MoEE on 24 November 2010.[56] The EIA was submitted to MONREC on 23/1/13, but not much progress seems to have been made since then in view of local opposition to the project.[57,58] It is unlikely that the 2021 completion date will be achieved. Shweli 2 would be connected to Shweli 3 by a 70 km long 230 kV transmission line.

Nam Paw: The 20 MW Nam Paw HPP is being developed on the tributary with the same name that joins the Shweli left bank from the south at Muse Town on the Myanmar/PRC border. The powerhouse with an installed capacity of 20 MW will be located at the foot of the 54 MW high dam. The project will be developed by the Myanmar company Great Hor Kham (a listed company in the Yangon Stock Exchange) with headquarters in Muse, Shan State. The company web site[59] is unusually detailed and up to date about progress compared to other project web sites. Initially, following the completion of a pre-feasibility study prepared by Kunming Engineering Co. Ltd (KHIDI) in October 2013, the Company signed a MoU with the Shan State Government on 7 October 2014.

The Company engaged Hunan Hydro Power Design Institute to carry out the feasibility study in November 2014, and Myanmar Sustainable Development of Engineering Services (MSDES) in April 2015 to carry out the ESIA. It further engaged SYDRO Consult of Germany on 18 November 2015 to carry out a dam-break analysis, which resulted in an Emergency Preparedness Plan following discussions with local task forces and village administrations. Muse Town is downstream of the dam.

However, since the Company planned to connect the power plant to the national grid, the Electricity Law of October 2014 (Section 4 Article 9) states that the developer needs a permit from the Union Government. The Company signed the MoA with the Union Government on 16 March 2016 for a BOT with a 50-year concession with up to 20 years extension. The company is negotiating the PPA with MoEE. Project is estimated to cost USD40.6 million with an IRR of 9%. The web-site further states that the project company will provide 1% of its net profits to Corporate Social responsibility (CSR) and 2% to the environmental management plan (EMP). Construction of preliminary works started on 27 April 2015 with access roads, power supply, and construction camp. Construction proper is scheduled to start in December 2017. The company is considering investing in three more hydropower projects (names not yet made public). The company is involved in Shweli 3 as contractor. The project is scheduled to be completed by 2019 according to data obtained from MoEE; 2010-21 is more realistic.

5.3.5 Ma Gyi Chaung

The Ma Gyi Chaung rises in the Shan state and, as it flows towards the Ayeyarwady, forms the border between Mandalay Region and Shan State for much of its length. It has a catchment area of 4,341 km^2

[56] https://democracyforburma.wordpress.com/2010/12/03/shweli-2-hydropower-project-and-bilin-hydropower-project-were-awarded-to-asia-world-company-limited-for-the-construction/
[57] http://www.burmalibrary.org/docs13/Sheweli_Under_Siege(en)-red.pdf
[58] https://www.earthrights.org/sites/default/files/publications/China-in-Burma-update-2008-English.pdf
[59] http://www.greathorkham.com/?q=en/node/267

and joins the Ayeyarwady about 33 km upstream of Mandalay (Figure 5.7). The identified hydropower potential in the sub-basin is 89 MW.

5.3.5.1 Existing Hydropower Plants

Table 5.25: Ma Gyi Chaung - Existing Hydropower Characteristics

Power Plant	Stage	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Country of Developer	Year
Sedawgyi	Existing	25	134	47	448	41	16	-	MoALI	1989

Note: NP = Not provided; (*): "E": Existing, "C": under construction

Sedawgyi: The third largest hydropower plant built in the country after the Baluchaung II was the ADB-financed[60] 25 MW multipurpose Sedawgyi hydropower dam on the Ma Gyi Chaung, in Pyinoolwin District, Mandalay Region. The water discharged through the turbines at the Sedawgyi reservoir is diverted for irrigation at a weir about 4 km downstream. The Ma Gyi Chaung joins the Ayeyarwady about 30 km upstream of Mandalay City. It was built and is being operated by MoALI. It is connected to the Kyaukpahto s/s by a 212 km long 132 kV transmission line.

5.3.5.2 Planned Hydropower Project

Table 5.26: Ma Gyi Chaung - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Upper Sedawgyi	64	NP	73	593	24	NP	NP	S	0

(NP) not provided; (#): S: storage, ROR: run of river

Table 5.27: Ma Gyi Chaung - Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Upper Sedawgyi	NP	NP	NP	-	MoALI	-	NP

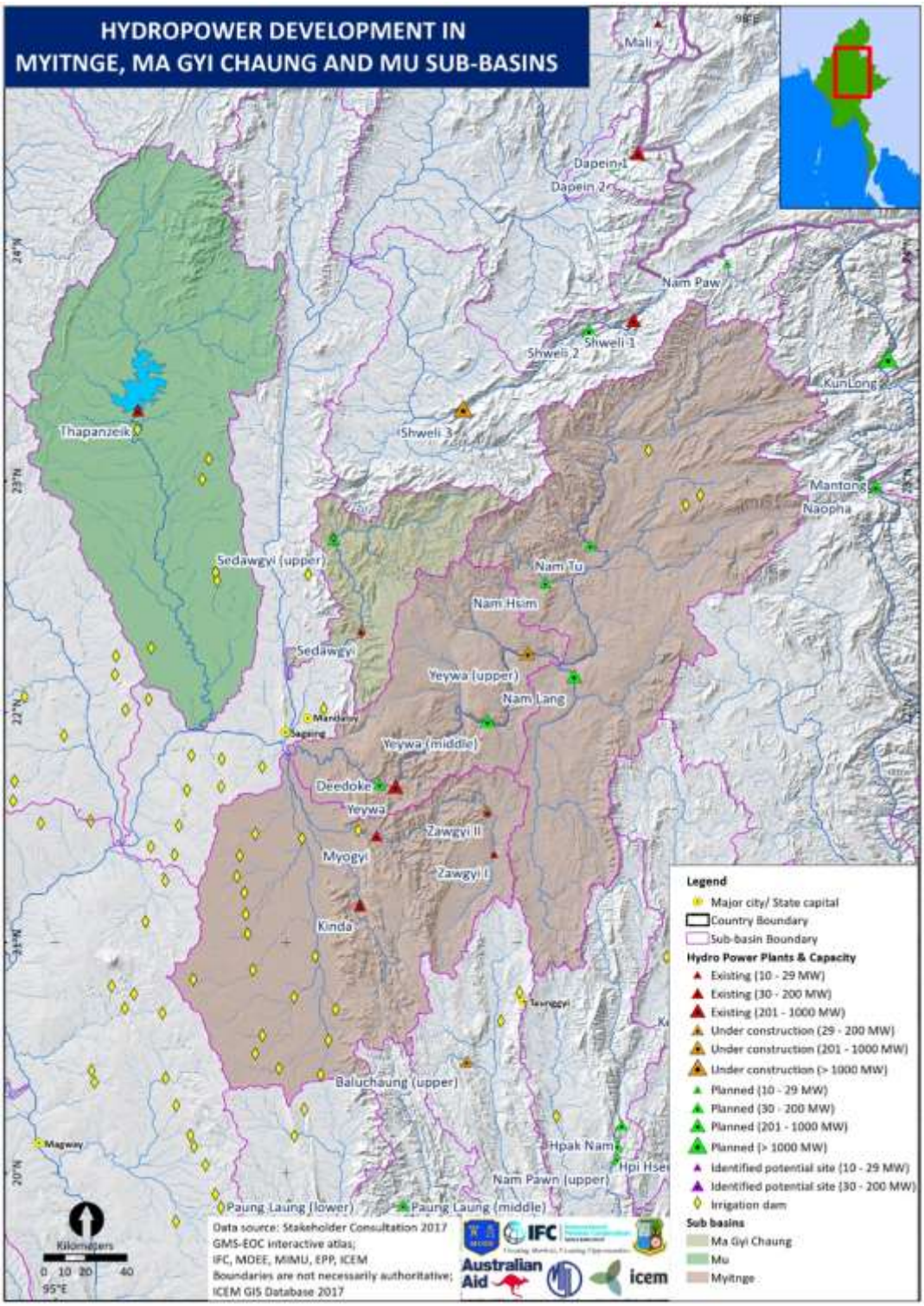
Upper Sedawgyi: MoALI is planning one multipurpose dam about 13 km upstream of Sedawgyi dam in Shan State. The 73 m high Upper Sedawgyi dam will also include a 64 MW hydropower plant. The reservoir created by the dam would inundate 24 km^2 and store 593 hm^3. It is not clear when construction would start as construction depends on government budget allocation. The project would be connected to two substations (s/s) by 132 kV transmission lines: Kyaukpahto s/s 212 km away, and Aungpinle s/s 48 km away.

[60] https://www.adb.org/sites/default/files/project-document/72939/36112-mya-pcr.pdf - financing of electro-mechanical equipment.

5.3.6 Myitnge Sub-basin

The Myitnge River is the largest tributary entering the Ayeyarwady from the east with a catchment area of 47,023 km^2. The Myitnge River joins the Ayeyarwady a few kilometres downstream of Mandalay City. It has two tributaries joining it from the south close to the confluence with the Ayeyarwady: the Zawgyi River and the Panlaung Chaung. The availability of flows is relatively low at around 16 l/s/km^2 compared with rivers in the north of the Ayeyarwady Basin that provide about 70 - 100 l/s/km^2. The identified hydropower potential in the sub-basin is 2,292 MW.

Figure 5.8: Myitnge River, Ma Gyi Chaung and Mu River hydropower development



5.3.6.1 Existing Hydropower Plants

Table 5.28: Myitnge Sub-basin - Hydropower Facility Characteristics

River	Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Myitnge	Yeywa (Upper)	C	280	1,409	97	342	26.94	60	0.3	MoEE	2021
	Yeywa	E	790	3,550	132	2,607	59.00	75	-	MoEE	2010
Myitnge	**Sum**		**1,070**	**4,959**		**2,949**	**85.94**	**135**	**-**		
Zawgyi	Zawgyi I	E	18	35	-	-	-	-	1.7	MoEE	1995
	Zawgyi II	E	12	30	44	639	38.47	8.2	-	MoEE/ MoALI	1998
	Myogyi	E	30	136	79	444	22.72	10.7	-	MoALI	2015
Zawgyi	**Sum**		**60**	**201**		**1,083**	**61.19**	**18.9**	**1.7**		
Panlaung Chaung	Kinda	E	56	165	72	1,078	28.57	13.3		MoEE	1985
	Total		**1,186**	**5,325**	**31 - 132**	**5,110**	**175.70**	**167.2**	**1.7**		

(*): "E": Existing, "C": under construction

Yeywa: The largest hydropower plant in Myanmar, the 790 MW Yeywa HPP on the Myitnge River in Pyinoolwin District, Mandalay Region, was completed in 2010. The 132 m high dam, the highest so far in Myanmar, created a 75 km long and narrow reservoir along its main branch with an area of 59 km^2 and storage of 2,607 hm^3. The powerhouse is at the foot of the dam and flows downstream of the dam depend on the power plant operation. MoEE operates this power plant. The power plant is connected by double-circuit 230 kV transmission lines to Belin s/s (38 km) and Meiktila s/s (118 km)

Upper Yeywa: MoEE is constructing a second hydropower plant, the 280 MW Upper Yeywa,[61] in the upper reaches of the Myitnge River (also called Nam Tu) in Pyinoolwin District, Mandalay Region. The RCC dam will be 97 m high and it will create a 26.9 km^2 reservoir storing 342 hm^3. The reservoir will be about 60 km long reaching Hsipaw Town in Shan State. A 12 m wide, 32 km long access road connects the main project site to the Mandalay - Lashio Highway at milepost 95/0. A 10 m diameter, 308 m long construction diversion tunnel on the right bank was completed and the river diverted on 9 March 2015. Two 12.5 m diameter headrace tunnels, 473 m and 538 m long respectively, are being excavated on the left bank.[62] MoNREC has approved the ESIA. Two villages with a total of 143 households and 486 inhabitants will be affected by the reservoir and need relocation to two existing neighbouring villages 13 km and 22 km away from the river. There have been recent protests against the completion of the dam.[63, 64] The power plant will be connected to Shwesaryan s/s by a double-circuit 230 kV transmission line 130 km long. The project is 28% completed.

Three hydropower plants, all in Taunggyi District, Shan State, have been built on the Zawgyi River, a tributary to the Myitnge River.

Zawgyi I: The 18 MW run of river Zawgyi I HPP is the furthest upstream power plant; its low gate-less weir diverts water to a powerhouse 1.7 km downstream. Inundation and storage is minimal. The power plant is connected to Aungthapye s/s by a 76 km long 66 kV transmission line.

[61] MoEE, "Upper Yeywa Hydropower Project – Presentation on Project Implementation", August 2017
[62] Main dam, power intake, headrace tunnel, powerhouse and resettlement works are being implemented.
[63] http://english.panglong.org/2016/11/29/hundreds-protest-dam-on-namtu-river/
[64] http://www.mizzima.com/news-domestic/new-report-calls-halt-dams-namtu-river

Zawgyi II: The next hydropower plant downstream, the 12 MW Zawgyi II, is part of a multipurpose earth dam 44 m high that created a 8.2 km long reservoir with a surface area of 38.5 km^2 and 639 hm^3 storage. There have been problems filling the reservoir. The power plant is connected to Zawgyi I by a 23 km long 66 kV transmission line.

Myogyi: The Zawgyi River is relatively steep dropping about 400 m as the river flows through a mountainous area from Zawgyi II for about 70 km (5.7 m/km) into the multipurpose Myogy**i** reservoir owned by MoALI. The 79 m high dam created a 10.7 km long reservoir that inundates 23 km^2 and stores 444 hm^3. At the foot of the dam, there is a 30 MW power plant. Downstream of the Myogyi dam, at least five diversion weirs extract water onto an irrigation system, parts of which has existed since the eleventh century, before reaching the Myitnge River. The power plant is connected to Taungtawgwin s/s by a 16 km long 33 kV transmission line.

Kinda: The second large-scale hydropower plant built in the country after the Baluchaung II is the 56 MW multipurpose Kinda hydropower plant completed in 1985 on the Panlaung Chaung, in Taunggyi District, Shan State. The 72 m high dam has created a 13.3 km long reservoir. The water released from the Kinda dam and power plant is diverted to two irrigation canals at a weir close to Ingon Village some 17 km downstream of the dam. Before it joins the Myitnge River a few kilometres upstream of the confluence with the Ayeyarwady, at least three more irrigation weirs divert water from the Panlaung Chaung. On close observation, satellite imagery of the river shows that the river has been negatively affected, in some case reducing its size and hardly visible, while nearby canals can be easily seen. The power plant is connected to two substations by 132 kV transmission lines: Ingon (73 km) and Thazi (47 km).

5.3.6.2 Planned Hydropower Project

There are five hydropower projects being considered in the Myitnge Sub-basin: two on the Myitnge River and three upstream from Upper Yeywa.

Table 5.29: Myitnge Sub-basin - Planned Projects - Key Data

River	Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Myitnge	Middle Yeywa	700	3,253	160	454	11	70	NP	NP	0%
	Deedoke	77	338	27	NP	NP	19	NP	NP	0%
Nam Tu/Myitnge	Nam Tu	100	410	114	NP	NP	4	NP	NP	0%
Tributaries to Myitnge	Nam Hsim	30	NP	NP	NP	NP	NP	NP	NP	0%
	Nam Lang	210	NP	NP	NP	NP	NP	NP	? NP	0%
Sum		**1,117**	**4,001**		**>454**	**>11**	**>93**	**NP**		

(NP) not provided; (#): S: storage, ROR: run of river

Table 5.30: Myitnge Sub-basin - Planned Projects - Development Process

River	Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Myitnge	Middle Yeywa	n.a.	MoU	2/7/14	SN Power	NP	Norway	2020
	Deedoke	18/2/16	MoU	20/11/14	Andritz Hydro	NP	Austria	2020
Tributaries to Myitnge	Nam Tu	NP	Local MoU	7/4/14	-	NCEH	-	2021
	Nam Hsim	n.a.	MoU	9/3/16	PCR	SE	PRC	2020
	Nam Lang	n.a.	MoU	9/3/16	PCR	SE	PRC	2020

Middle Yeywa: Following the MoU signing on 2 July 2014, the Middle Yeywa HPP being developed by SN Power, Norway is being studied to feasibility level. The project, located in Nawgn Khio Township, Shan State, comprises a 160 m high RCC/arch dam that would create a narrow 70 km long reservoir inundating 11 km^2 and storing 454 hm^3. The underground powerhouse about 200 m from the dam would have an installed capacity of 700 MW. An environmental flow outlet with a discharge of 45 m3/s has been incorporated in the design. MoEE's schedule indicates it should be completed by 2021, but this is unlikely now. The power plant would be connected to the 500 kV Meikhtila s/s (length and voltage level of transmission line not yet decided)

Deedoke HPP: MoEE and Andritz Hydro, Austria, signed the MoU on 20 November 2014. The developer submitted the EIA to MONREC on 18 February 2016. The proposed 27 m high dam with a run of river 77 MW power plant would be located downstream of Yeywa taking advantage of the river regulation of the Yeywa reservoir. It is scheduled for completion by 2020-21. The power plant would be connected to Yeywa s/s by a 21 km long 230 kV transmission line.

Nam Tu: MoEE and NCEH, Myanmar, signed a local MoU on 7 April 2014. The proposed Nam Tu HPP on the upper reaches of the Myitnge (also called Nam Tu) in Hsipaw Township, Shan State, is planned with a dam 114 m high and a power plant with an installed capacity of 100 MW. It is scheduled for completion in 2020, but this does not appear to be realistic.

Nam Hsim: MoEE and PCR, PRC, signed a MoU on 9 March 2016 for the development of the 30 MW Nam Hsim HPP in Shan State. No technical details are available about the project.

Nam Lang: MoEE and PCR, PRC, signed a MoU on 9 March 2016 for the development of the 160 MW Nam Lang HPP in Shan State. No technical details are available about the project.

5.3.7 Mu Sub-basin

Thapenzeik: This multipurpose facility owned by MoALI on the Mu River incorporates a 30 MW power plant. It joins the Ayeyarwady from the west about 40 km downstream of Mandalay City. Its 33 m high dam created the largest man-made reservoir in Myanmar to date with an inundation of 397 km^2. It is 43 km long along its main branch. A diversion weir about 11 km downstream of the dam diverts water for irrigation on both banks of the Mu River. Although the Ayeyarwady has been little used for irrigation in the central dry zone, its tributary, the Mu River, has been used for this purpose since the 9th century. The Mu Valley Irrigation Project is among the largest in the country. It permits the dry-season cropping of corn, peanuts, sesame, wheat, cotton, millet, and other dry crops. About one-sixth of the total rice grown in Myanmar comes from the irrigated areas of Mandalay, Sagaing, and Magwe divisions.[65] The power plant is connected to Ngapyadaing s/s by a 53 km long 132 kV transmission line.

[65] https://www.britannica.com/place/Irrawaddy-River

There are presently no plans to develop more large-scale hydropower projects in the Mu River or any of its tributaries.

Table 5.31: Mu River - Power Plant Characteristics

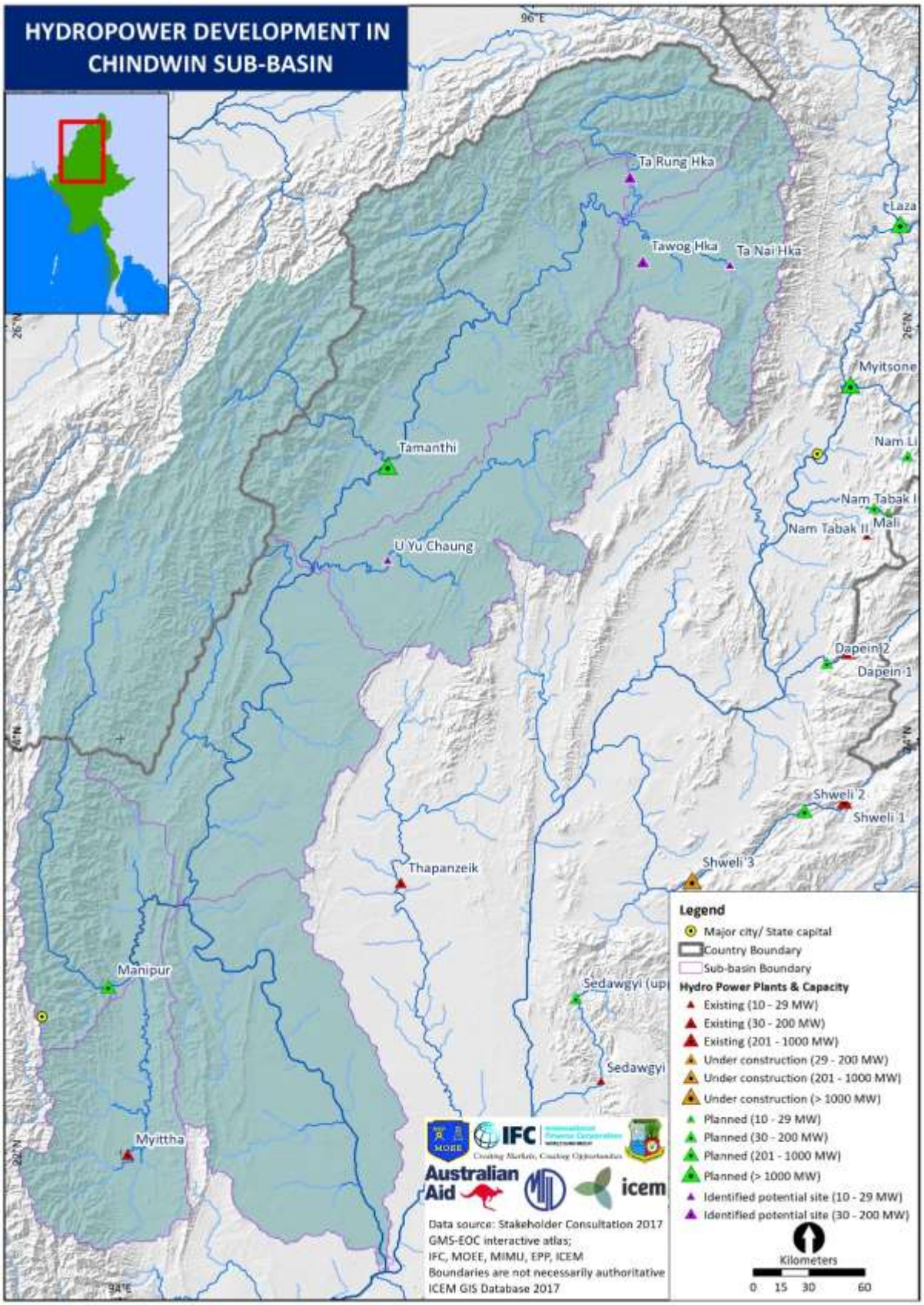
Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Country	Year
Thapenzeik	E	30	117	33	3,552	397.05	42.8	-	MoEE/ MoALI	2002

(*): "E": Existing, "C": under construction

5.4 Chindwin Sub-basin

The 1,207 km long Chindwin has a catchment area of 114,687 km^2, of which about 16% is in Manipur State, India. Several tributaries enter Myanmar from India to the west, the largest being the Manipur River, a tributary to the Myittha River, itself a tributary to the Chindwin (Figure 5.9). The identified hydropower potential in the sub-basin in Myanmar is 1,847 MW.

Figure 5.9: Hydropower development in the Chindwin Sub-basin



5.4.1 Existing Hydropower Plants

Table 5.32: Chindwin Sub-basin - Power Plant Characteristics

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Myittha	E	40	170	63	325	NP	NP	-	MoALI	2017

(*): "E": Existing

Myittha: The 40 MW Myittha multipurpose project in Gangaw District, Magway Region is on the Myittha River, a tributary approaching from the south to the Chindwin right hand bank. It has been completed by MoALI in 2017. It comprises a 63 m high earth dam that will create storage of 325 hm^3 and inundate 12 km^2. The power plant will be connected to Gangaw s/s by a 40 km long 66 kV transmission line.

5.4.2 Planned Hydropower Project

There are two hydropower plants identified in the Chindwin Sub-basin, one on the Chindwin mainstream and the other on the Manipur River, a tributary to the Myittha River.

Table 5.33: Chindwin Sub-basin - Planned Projects - Key Data

HPP	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Retention Period (days)	Type (#)	Export (%)
Htamanthi	1,200	~6,307	74	20,925	509	NP	NP	S	NP
Manipur	380	1,903	168	1,554	NP	45	NP	NP	NP
Tawog Hka	50	NP	NP	NP	NP	NP	NP	NP	NP
Ta Rung Hka	150	NP	NP	NP	NP	NP	NP	NP	NP
Ta Nai Hka	15	NP	NP	NP	NP	NP	NP	NP	NP
U Yu Chaung	12	NP	NP	NP	NP	NP	NP	NP	NP
Sum	**1,806**	**>8,210**		**>22,479**	**>509**	**>45**			

(NP) not provided; (#): S: storage, ROR: run of river

The four last proposed projects in the table, which location is shown in Figure 5.9, have only been identified as potential sites and the installed capacity is a preliminary estimate.[66]

[66] Earlier studies had identified two more large hydropower projects on the Chindwin Mainstem (the 520 MW Mawlaik HPP and the 660 MW Shwezaye HPP), but these have now been excluded form MoEE's official hydropower development list.

Table 5.34: Chindwin Sub-basin - Planned Projects - Development Process

HPP	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Htamanthi	n.a.	Pre-MoU	None	NHPC	NP	India	Suspended
Manipur	n.a.	MoU	18/9/14	CHEC	Sein	PRC	2020

Htamanthi: NHPC Ltd[67] proposed to develop the 1,200 MW Htamanthi HPP on the Chindwin at Hkamti, Sagain Region. The project with a 74 m high dam would create a reservoir inundating 509 km^2 and storing 20,925 hm^3, almost 30% and 60% respectively larger than the Myitsone inundation and storage. The reservoir would significantly control flooding in the lower reaches of the Chindwin and Ayeyarwady. A Swiss firm carried out preliminary studies. The project lies in an area with high seismicity and the river carries significant amounts of sediment. The social and environmental impacts would also be significant with about 50 villages and two towns being severely affected. The project was suspended before a MoU had been signed.

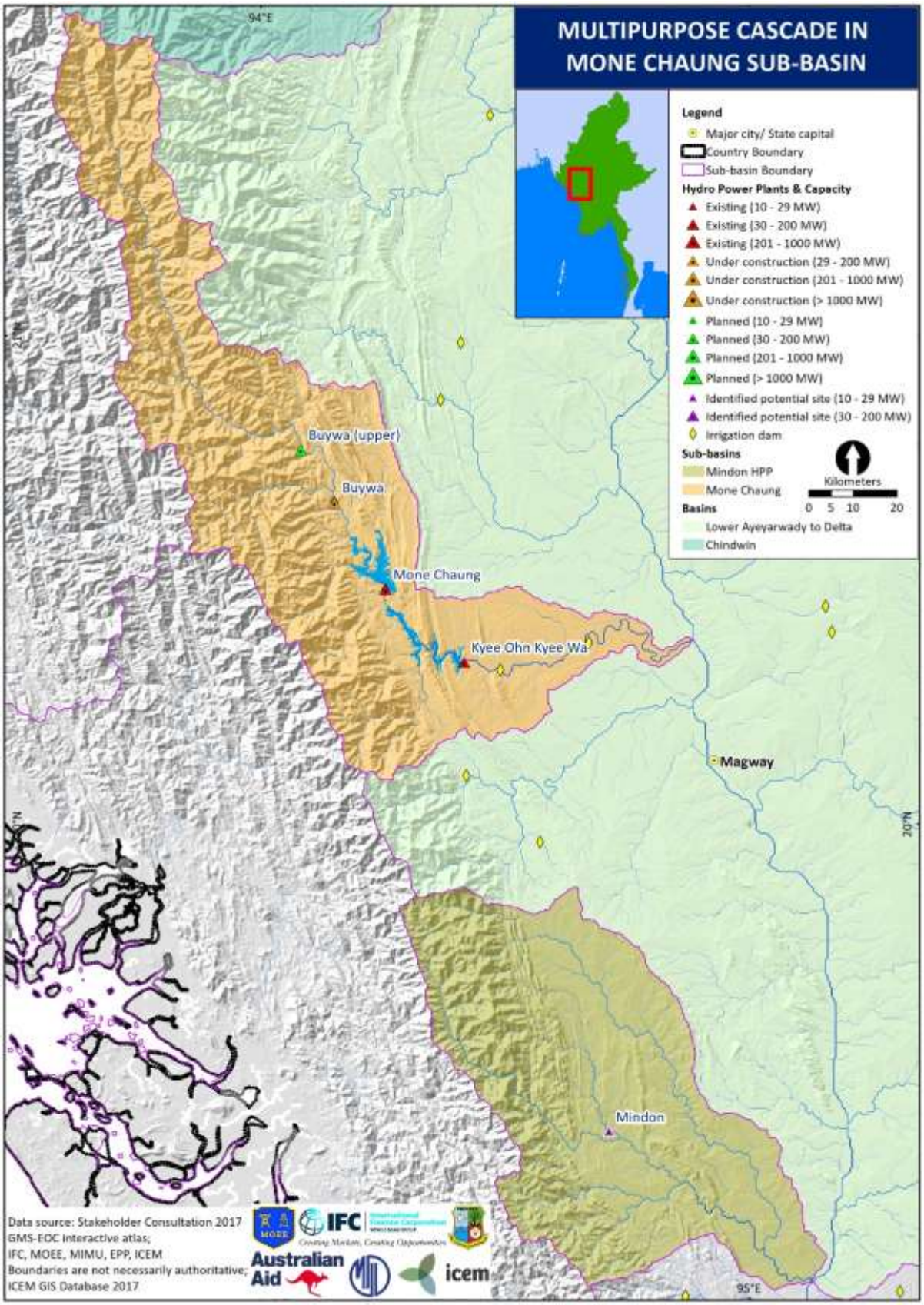
Manipur: the 380 MW Manipur HPP is in Falam District, Chin State on the Manipur River, a tributary to the Myittha. Manipur River originates in Manipur State, India and has been regulated by other reservoirs there. MoEE and the China Harbour Engineering Company with Sein of Myanmar signed a MoU on 18 September 2014. A year later, they submitted the feasibility study to MoEE. The Manipur project would have a 168 m high dam with a reservoir storing 1,554 hm^3. It is unlikely the project will be completed in 2021. The power plant would be connected to Gangaw-Kalay s/s by a 32 km long 230 kV transmission line.

5.5 Lower Ayeyarwady

The Lower Ayeyarwady stretches between the Chindwin confluences to the delta at a small village called Ngapiseik. The catchment area is about 92,930 km^2. The identified hydropower potential in the two sub-basins with hydropower potential in the sub-basin is 359 MW.

[67] Originally National Hydroelectric Power Corporation, a Government of India Enterprise established in 1975.

Figure 5.10: Hydropower development in the Lower Ayeyarwady



Note: Locations of Buywa and Upper Buywa are approximate.

There are no hydropower plants on the main stem of the Lower Ayeyarwady, but there are two multipurpose dams with hydropower capacity exceeding 10 MW on the Mone Chaung, a western tributary to the lower Ayeyarwady downstream of the confluence with the Chindwin River: the Mone Chaung and the Kyeeon Kyeewa HPPs (Figure 5.10). MoALI is constructing one multipurpose dam, and planning a second one, both upstream on Mone Chaung. One more potential hydropower site, the 18 MW Mindon HPP, has been identified in a sub-basin south of the Mone Chaung (See Figure 5.10)

5.5.1 Existing Hydropower Plants

There are three multipurpose dams owned by MoALI on the Mone Chaung incorporating a hydropower plant operated by MoEE. One, the Buywa dam, is still under construction.

Table 5.35: Mone Sub-basin - Power Plant Characteristics

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-	Country /Owner	Year
Buywa	C	42	NP	46	209	38	NP	-	MoALI	2018
Mone Chaung	E	75	330	61	832	42	19	-	MoEE/ MoALI	2002
Kyeeon Kyeewa	E	74	370	50	571	33	30	-	MoALI	2012
Sum		**191**	**>700**		**1,612**	**113**	**49**			

(*): "E": Existing, "C": under construction; "NP": not provided

Mone Chaung: The Mone Chaung multipurpose facility completed in 2002 by MoALI consists of a 61 m high rock-fill dam with a 42 km^2 reservoir that stores 832 hm^3. The 75 MW power plant is located at the toe of the dam and discharges into the Kyeeon Kyeewa reservoir. The power plant is connected to Chauk s/s by a 160 km long 132 kV transmission line.

Kyeeon Kyeewa: The Kyeeon Kyeewa multipurpose facility completed in 2012 has a 50 m high earth dam that created a reservoir inundating 33 km^2 and storing of 571 hm^3. Its 74 MW power plant is located at the toe of the dam. Two diversion weirs divert water for irrigation downstream of the Kyeeon Kyeewa power plant before the Mone Chaung reaches the Ayeyarwady. The combined inundation length reaches 50 km. The power plant is connected to Mann s/s by a 70 km long 132 kV transmission line.

Buywa: The Buywa multipurpose facility being built by MoALI about 21 km upstream of Mone Chaung is scheduled for completion in 2018. The 46 m high dam will creates a reservoir that inundates 38 km^2 and stores 209 hm^3. The 42 MW power plant is at the foot of the dam.

5.5.2 Planned Hydropower Project

One multipurpose dam to be built by MoALI is being planned. It will incorporate a hydropower plant to be operated by MoEE. Another hydropower project, the 18 MW Mindon HPP, has been identified as a potential project, but the SEA Team has no details on this project.

Table 5.36: Lower Ayeyarwady Sub-basins - Planned Projects - Key Data

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Country /Owner	Year
Upper Buywa	P	150	534	138	721	76	NP	-	MOALI	NP
Mindon	I	18	NP	NP	NP	NP	NP	NP	NP	NP
Sum		**168**	**>534**		**>721**	**>76**	**NP**			

Upper Buywa: The Upper Buywa multipurpose facility is being developed by MoALI is upstream of the Buywa dam.[68] The 138 m high dam to be operated by MoEE will have a power plant of 150 MW. The reservoir will inundate 76 km^2 and store 721 hm^3. Construction is dependent of GOM budgetary allocations.

5.6 Thanlwin Basin

The 2,400 km long Thanlwin River, the second longest river in South-East Asia after the Mekong, flows from 4,000 m asl on the Tibetan Plateau[69] to the east then south through Yunnan in the PRC, entering Myanmar in the northeast and flowing south into the Bay of Martaban. The upper 53% of this 324,000 km^2 narrow and mountainous basin is in the PRC, 42% in Myanmar and 5% in Thailand. The basin discharges an average of 4,978 m^3/s. A 130 km section of the river forms the border between Myanmar and Thailand. The Thanlwin basin has four major tributaries with existing and identified large-scale hydropower potential in Myanmar:

- Nam Ma - joining from the east
- Nam Hka - joining from the east
- Nam Teng - joining from the west
- Nam Pawn - joining from the west (including its tributary, the Baluchaung)

The Thanlwin basin has 302 MW installed hydropower capacity in four existing power plants, with a further two under construction totalling 81 MW (Table 5.38). These projects are all located on the Baluchaung and Nam Teng. An additional 15,980 MW of hydropower-installed capacity is planned in 12 projects. The identified hydropower potential in the basin in Myanmar is about 16,500 MW.

[68] The coordinates of the project site have not been made available. The approximate location in the GIS map has been estimated from the catchment area (2,305 km^2) in the HydroSHEDS database

[69] The Thanlwin River is called "Nujiang" ('Nu') in the PRC and "Salween" in Thailand

Figure 5.11: Hydropower development in the Thanlwin Basin, Myanmar

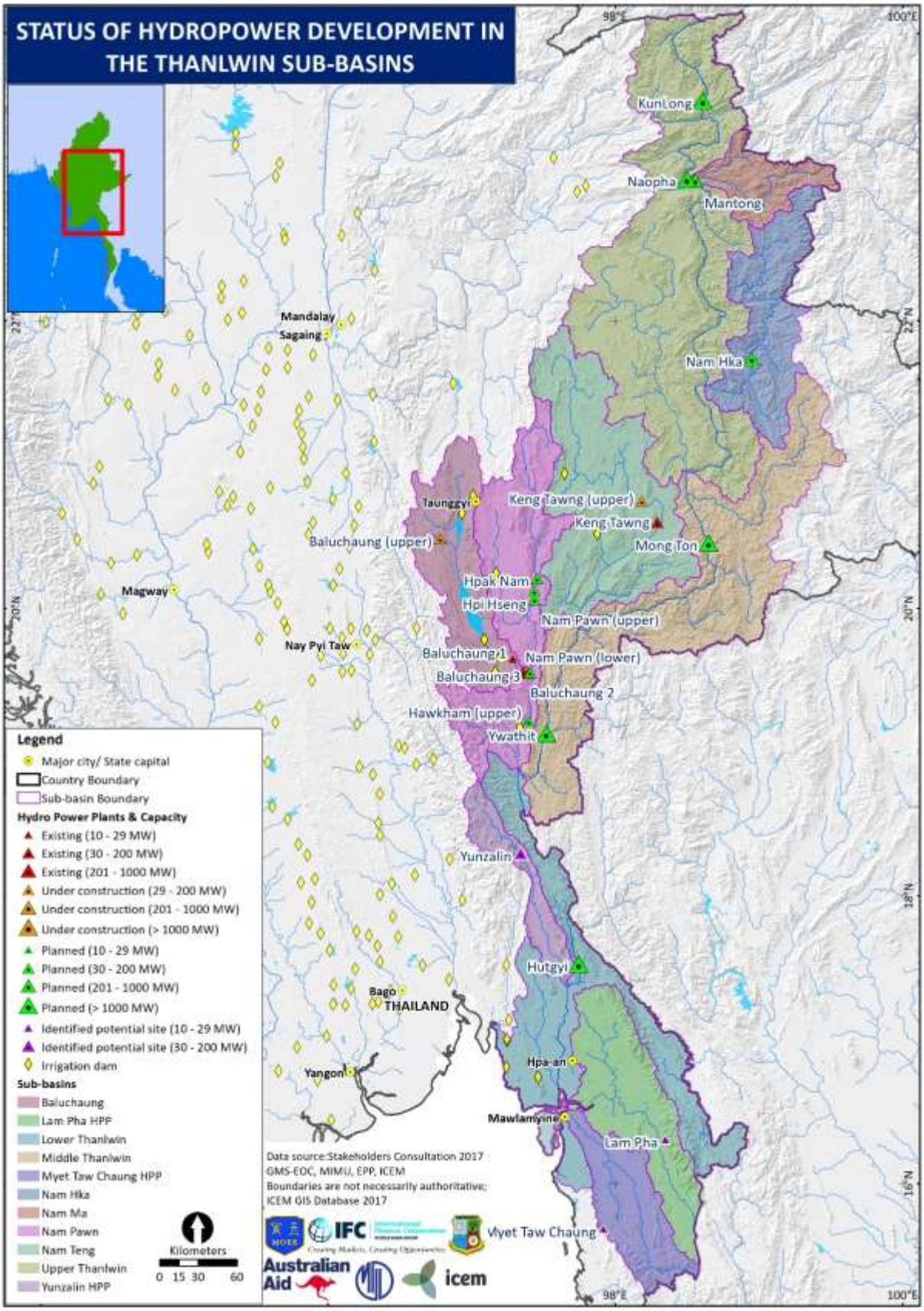


Table 5.37: Thanlwin Basin - Hydropower Development (>10 MW)

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Existing and under construction	6	383	2,423	0-35	193	10	>1
Planned	15	16,110	85,457	10-241	49,824	>1,088	>844
Sum	**21**	**16,493**	**87,880**	**0-241**	**50,017**	**>1,098**	**>845**

Table 5.38: Thanlwin Basin - Existing and Under Construction Hydropower Plants (>10 MW)

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Nam Teng	2	105	609	NP	189	0.1	1.0
Baluchaung	4	278	1,814	0-35	4	9.8	>0.2
Sum	**6**	**383**	**2,423**		**193**	**9.9**	**>1.2**

Note: NP = Data not provided

Table 5.39: Thanlwin Basin - Planned Hydropower Projects (>10 MW)

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Mainstream	**5**	**14,960**	**80,868**	**51-241**	**47,269**	**1,002**	**>691**
Tributaries	**7**	**1,150**	**4,589**	**10-120**	**2,555**	**>86**	**>153**
Nam Ma	1	225	936	109	1,215	11	86
Nam Hka	1	210	937	120	450	75	NP
Nam Pawn	5	585	2,716	10-88	890	>0	>67.2
Yunzalin	1	100	NP	NP	NP	NP	NP
Lam Pha	1	20	NP	NP	NP	NP	NP
Myet Taw Chaung	1	10	NP	NP	NP	NP	NP
Sum	**15**	**16,110**	**>85,457**	**10-241**	**>49,824**	**>1,088**	**>844**

5.6.1 Thanlwin Mainstream

Five hydropower plants with a total installed capacity of 14,960 MW are being planned on the Thanlwin mainstream (Table 5.41 and Table 5.42).[70] Three proposed dams are large, with dams

[70] The 4,540 MW Wei Gyi HPP between Ywathit and Hutgyi initially identified by Thailand on the border between Myanmar and Thailand has been excluded from the SEA as MoU has been terminated because it interferes with the Ywathit HPP.

higher than 100 m: Mong Ton (241 m), Hutgyi (118 m) and Kun Long (103 m). The projects are being proposed mainly for export. If built, the projects would inundate more than 1,000 km^2 of land along more than 690 km of river storing about 47,300 hm^3.

Table 5.40: Proposed Thanlwin Mainstream Project Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Reservoir length (km) (*)	Export (%)
Kun Long	1,400	7,142	100	659	65.40	1	ROR	55	50%
Naopha	1,200	6,182	90	813	23.37	1	ROR	110	50%
Mong Ton	7,000	34,700	241	37,887	870.00	150	S	~380	90%
Ywathit	4,000	25,519	51	7,401	43.47	11	S	~130	NP
Hutgyi	1,360	7,325	118	509	NP	0.5	ROR	16	90%
Sum	**14,960**	**80,868**	**51-241**	**47,269**	**>1,002**			**>691**	

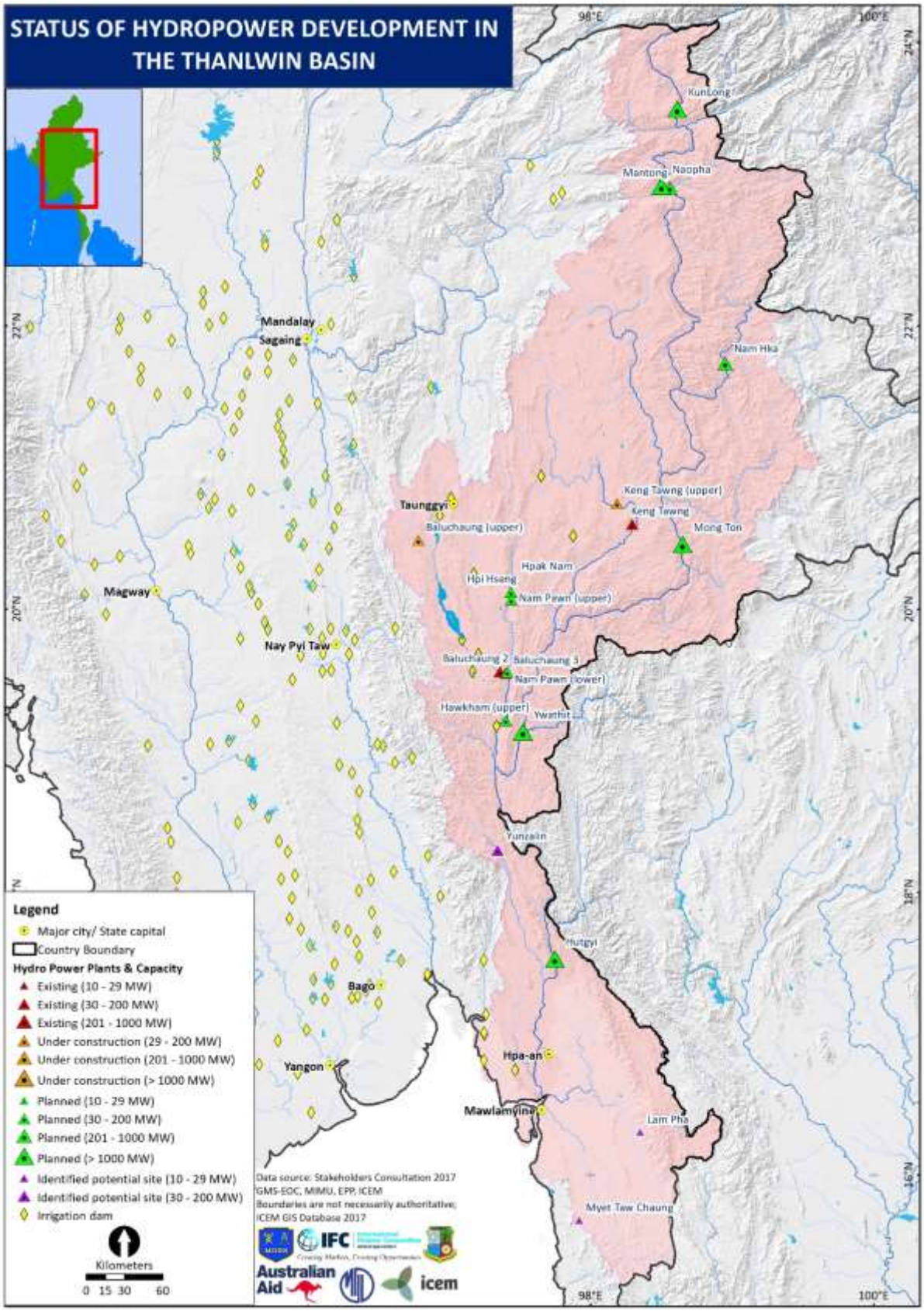
(*): Reservoir lengths have been measured in Google Earth based on location of dam and FSL; (NP): Data not available; (+) ROR: run of river, S: storage.

Table 5.41: Proposed Thanlwin Mainstream Project Development Stage

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Scheduled for
Kun Long	5/04/12	JVA	21/05/14	Hanergy YN	MPC	PRC	2023
Naopha	NP	MoA	22/05/14	HydroChina	IGOEC	PRC	2026
Mong Ton	NP	MoU	10/11/10	Three Gorges/ EGATi	-	PRC/THA	2030
Ywathit	NP	MoA	18/01/11	CDOI	STH	PRC	2030
Hutgyi	NP	MoA	24/04/10	Sinohydro/ EGATi	IGOEC	PRC/THA	2020

(*): Not yet applicable as projects are still undergoing pre-feasibility study; (NP): Data not provided.

Figure 5.12: Proposed dams on Thanlwin mainstream



Kun Long: the 1,400 MW Kun Long HPP at Kun Long, Shan State, is at an advanced state of development and has reached the JVA stage, signed by MoEE and Hanergy YN/MPC in May 2014. It would have a 103 m high dam that creates a 65.4 km^2 reservoir storing 691 hm^3. An EIA was

prepared by HydroChina and submitted to MONREC in April 2012, but this has not been made public and it is not clear if MONREC has approved it. Fifty percent of the power from the project (1,260 MW) will be exported to PRC. Preliminary works started at the site in 2015, but stopped when armed conflict broke out. The project is due for completion in 2024. The power plant would be connected to Theinni s/s by a 68 km long 230 kV double-circuit transmission line.

Naopha: the 1,200 MW Naopha HPP at Lashio, Shan State, downstream of Kun Long has a 90 m high dam that will create a 110 km long reservoir. This project will export 600 MW (50%) of the power to PRC and supply the other half to Myanmar. MoEE and Hydro China/IGOEC signed the MoA in May 2014, but the EIA does not appear to have been submitted to MONREC for approval. The project is scheduled for completion in 2027.[71]

Mong Ton: the proposed 7,000 MW Mong Ton HPP, located downstream of Naopha at Monghsat, Shan State, with a 241 m high dam[72] would create a 380 km long 870 km^2 reservoir[73] storing an estimated 37,887 hm^3. By volume, the reservoir would be the largest in Myanmar and about the 26th largest in the world[74], slightly smaller than the Three Gorges reservoir (39,300 hm^3).[75] This project was being jointly developed by Chinese Consortium China (CSC - consisting of China Three Gorges Corporation (CTG),[76] Sinohydro and China Southern Power Grid (CSPG)), Electricity Generating Authority of Thailand International (EGATi), International Group of Entrepreneurs Company (IGOEC) of Myanmar and MoEE. The consortium signed a MoU with MoEE in November 2010, and submitted the feasibility study to MoEE in November 2013.[77] It is unclear if the EIA commenced by Snowy Mountains Engineering Corporation (SMEC) of Australia in October 2014 has been approved by MONREC.[78]

According to EGATs website the project design was modified at the request of GoM:[79] "*The original project has a generating capacity of 7,000 MW, but after the Government of Myanmar considered Feasibility Study Report, the Government of Myanmar requested developer to revising the project formulation by using Cascade Dams platform and reducing the height of the dam to reduce the impact on society and the environment*". EGAT states in the web-site that the proposed installed capacity is now 3,000 MW, with 90% of EGATi's share (900 MW) to be sold to EGAT in Thailand and the other 10% provided to Myanmar free of charge.

Recent alternative designs under discussion with MoEE indicate that the developer is considering two alternative cascade schemes, (a) a two-dam alternative (Mon Tong and Wangon); and (b) a three-dam alternative (Mon Tong, Wanpa and Nansu). Both alternatives would significantly reduce the volume of stored water and the area inundated, but would maintain the total length of the reservoirs to about 378 km, albeit at much smaller depths. Installed capacity would reduce by about 1,000 MW and 1,700 MW respectively.

The ground-breaking ceremony for the project at the start of the investigations was conducted in March 2007 (when the project was named Tasang HPP) but there has been little activity at the dam site since 2008 when construction stalled because of local opposition. The project is scheduled for completion in 2030.

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[71] http://www.naopha.com/about/

[72] It would have been about the 15th highest dam in the world.

[73] https://en.wikipedia.org/wiki/Tasang_Dam

[74] https://en.wikipedia.org/wiki/List_of_reservoirs_by_volume

[75] The Kariba dam on the Zambezi River between Zambia and Zimbabwe created in 1959 is the largest reservoir in the world by volume (180,600 hm^3). The Danjiangkou Dam on the Han River, a tributary to the Yangtze River in PRC, created in 1962 is the largest reservoir (51,600 hm^3) in Asia (20th in the world).

[76] http://www.mongtonhydro.com/eportal/ui?pageId=132108

[77] EGATi's website stated that in September 2015 MoEE had approved the feasibility report, but encouraged that the dam should be designed on safety basis and developer should adopt the cascade dams platform rather than single dam platform to relief environmental and social impacts. The revised project will be proposed to MoEE further.

[78] Environmental Impact Assessment and Social Impact Assessment Public Scoping Meeting was held in Taunggyi District on 10 March 2015 - no further information is available in the company website (http://www.mongtonhydro.com/)

[79] http://www.egati.co.th/en/investment/en-mongton.html

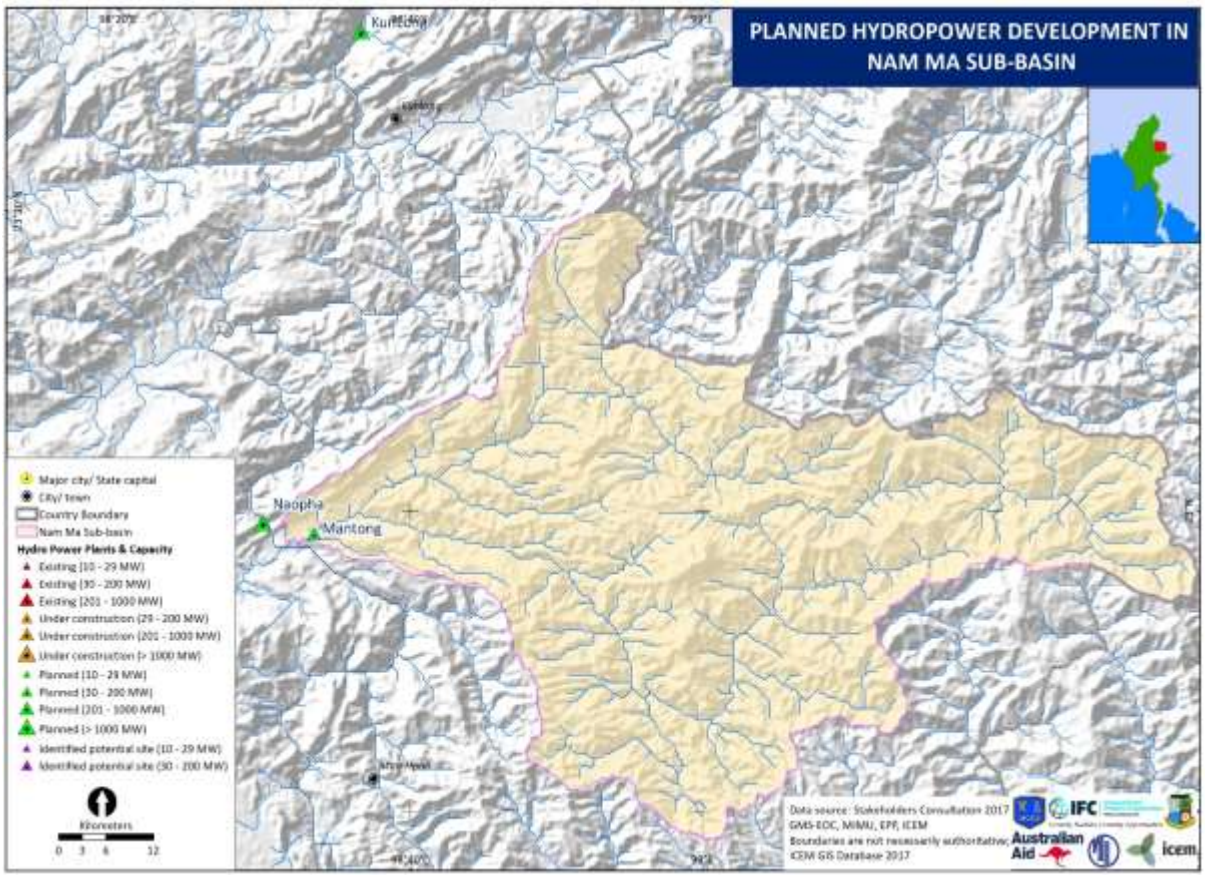
Ywathit: the 4,000 MW Ywathit HPP at Bawlake, Kayah State, downstream of Mong Ton, is proposed with a 51 m high dam creating a 130 km long reservoir. It would export 2,000 MW (50%) of the power to PRC. MoEE and CDOI/STH signed the MoA in January 2011. The EIA does not appear to have been submitted to MONREC for approval. The project in scheduled to be completed in 2030.

Hutgyi: the last hydropower project on the mainstream is the 1,200 MW Hutgyi HPP at Hpapun, Kayin State. The project would have a 118 m high dam that would create a reservoir inundating 27.1 km^2 and storing 509 hm^3. The project is in limestone area with uncertain seepage issues. MoEE signed a MoA with Sinohydro (holding 50.5%) and EGATi (holding 36.5%) in April 2010.[80] The EIA does not seem to have been submitted to MONREC for approval. The project is scheduled for completion in 2020, but at this stage that completion date is unachievable. Eighty seven percent (1,044 MW) of power is planned for export to Thailand. The power plant would be connected in Myanmar to Thaton s/s and Myainggyingu s/s by 230 kV and 33 kV transmission lines respectively.

5.6.2 Nam Ma Sub-basin

One project, the Mantong HPP, is being planned on the Nam Ma, a tributary that joins the Thanlwin from the east about 5 km downstream of Naopha. The unit flow is around 32 l/s/km^2, about half to a third that of the Ayeyarwady Headwaters.

Figure 5.13: Nam Ma hydropower development



[80] The remaining interest is held 10% by MoEE and 3% by IGOEC

Table 5.42: Nam Ma Proposed Project Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Reservoir length (km) (*)	Distance dam to power house (km)	Export (%)
Mantong	225	936	109	1,215	10.46	146	S	86	NP	50%

Table 5.43: Nam Ma Proposed Project Development Stage

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Scheduled for
Mantong	?	MoA	22/05/14	HydroChina	IGOEC	PRC	2024

Mantong: the 225 MW Mantong hydropower project, on the Nam Ma about 3 km upstream of the confluence with the Thanlwin, would create a 10.5 km^2 reservoir storing 1,094 hm^3 (Table 5.43) in two main branches, one 51 km long and the other 35 km long. The CFRD dam would be 109 m high. MoEE and HydroChina/IGOEC signed a MoA in May 2015 (Table 5.43), even though the EIA has not yet been submitted to MONREC. Fifty percent of the power is earmarked for export to PRC. The power plant would be connected to Theini s/s by a 105 km long double circuit 500 kV transmission line.

5.6.3 Nam Hka Sub-basin

One project is being planned on the Nam Hka, a tributary with a catchment area of 10,372 km^2 that rises at an elevation of around 1260 m in Myanmar, running south for about 70 km forming a border with PRC until it reaches the border town of Paunghsang when it enters Myanmar completely and joins the Thanlwin from the east into the proposed Mong Ton reservoir about 160 km upstream of the dam. The unit flow is around 20 $l/s/km^2$, about third to a quarter to that of the Ayeyarwady Headwaters.

Figure 5.14: Planned Hydropower Development in the Nam Hka Sub-basin

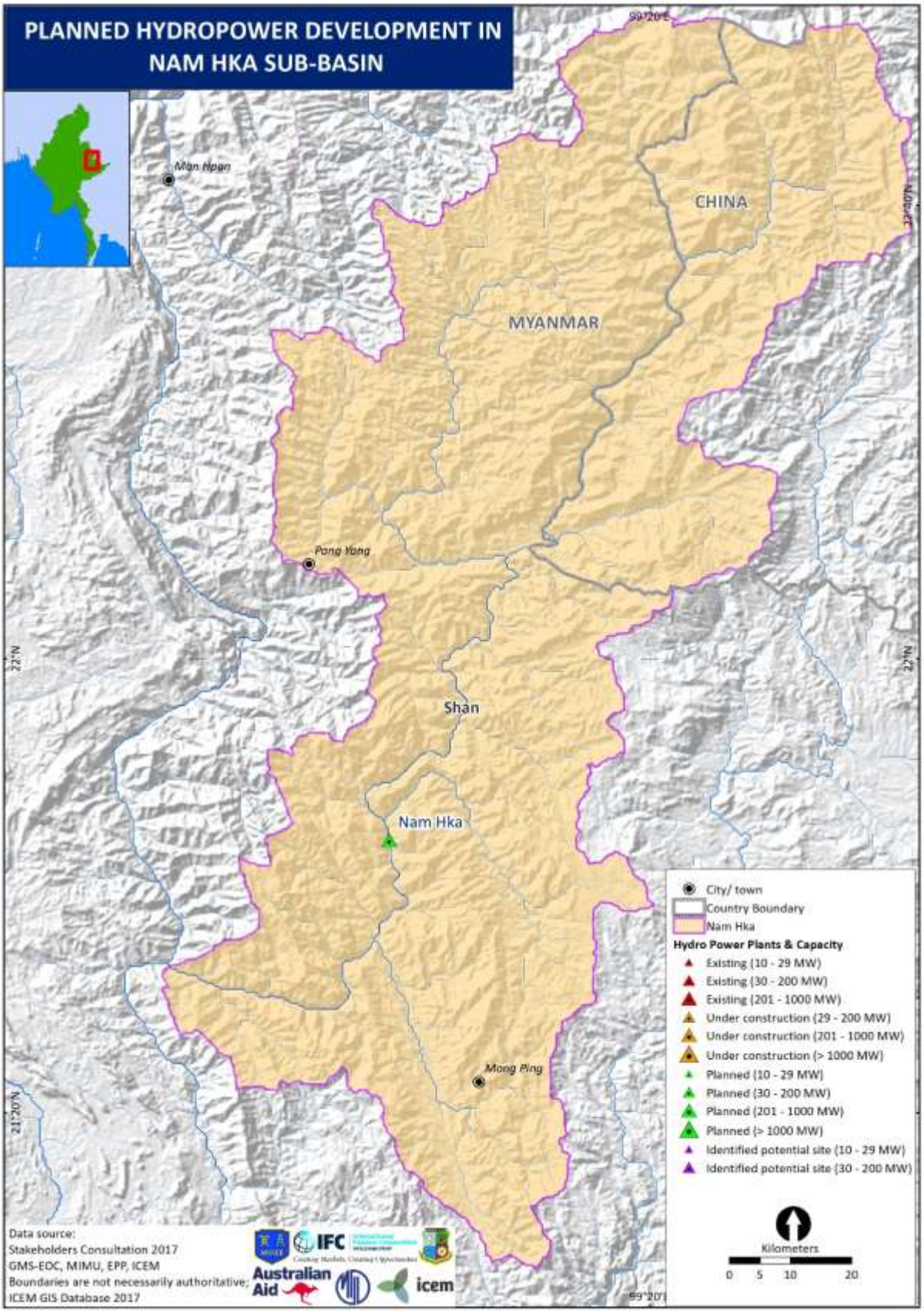


Table 5.44: Nam Hka Proposed Project Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Reservoir length (km)	Distance dam to power house (km)	Export (%)
Nam Hka	210	937	120	450	75.15	NP	NP	73 - 85	-	0%

Table 5.45: Nam Hka Project Development Stage

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Scheduled for
Nam Hka	?	MOU	27/9/07	YNIC	-	PRC	2025

Nam Hka: the 210 MW Nam Hka hydropower project is planned on the Nam Hka within Mong Sat Township about 60 km upstream of the confluence with the Thanlwin.[81] The project has a 120 m high dam that would create a reservoir with storage of 450 hm^3 and inundate 75 km^2. A MoU for the project was signed by Yunnan International Company Ltd. (YNIC), incorporated by China Southern Grid (CSG), and MoEE in September 2007, with a feasibility report submitted to MoEE in November 2010.

5.6.4 Nam Teng Sub-basin

The Nam Teng rises in the Shan Hills at around 1,150 m amsl north of Monkung, Shan State, and flows first roughly north-east and then southward for about 560 km before joining the Thanlwin from the west at Ta-Hsopteng in Linkhe District. Along its course it drops 1,010 m resulting in an average gradient of 1.8 m/km. Its catchment area is 15,342 km^2.

The only hydroelectric facilities greater than 10 MW in the Nam Teng Sub-basin are the existing Keng Tawng HPP and the under construction Upper Keng Tawng HPP, both close to Keng Tawng Town, developed for hydropower generation only.

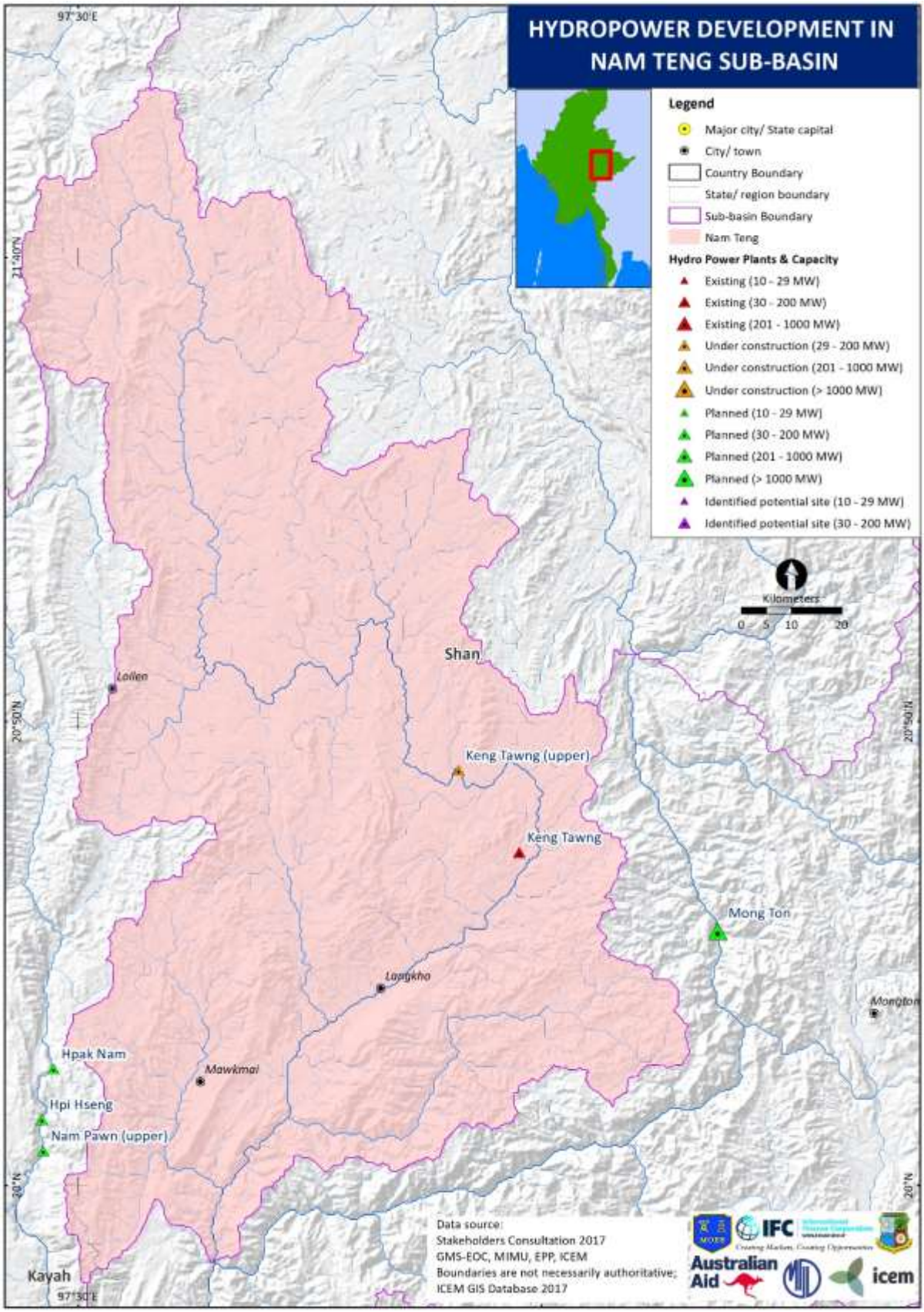
Table 5.46: Nam Teng - Power Plant Characteristics

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Country	Year
Keng Tawng	E	54	378	27	61	0.08	0.9	-	MoEE	2016
Upper Keng Tawng	C	51	231	56	128	NP	NP	NP	MoEE	2019
Sum		**105**	**609**	**27-58**	**189**	**>0.08**	**>0.9**			

(*): "E": Existing, "C": under construction

[81] The location shown in the map is approximate; it might be further south/downstream. The SEA Team was provided coordinates that locate the dam on a hill about 3 km west of the Nam Hka. We have positioned the dam due east of this location on the Nam Hka. However, at this location there is a possibility that the top of the dam may be at an elevation above the elevation of the Myanmar-PRC border town of Paunghsang. This indicates that the dam should be further downstream. The dam can only be positioned in the map up to about 12 km further downstream, or it would interfere with the Mong Ton reservoir (FSL 395 m). Since Nam Hka FSL is not available (only dam height), it is difficult to position the dam more accurately.

Figure 5.15: Nam Teng sub-basins



Keng Tawng: The 54 MW Keng Tawng HPP in Linkhe District, Shan State, is a storage facility[82] with a 27 m high concrete gravity dam,[83] a 2.2 km headrace canal on the right bank, a 792 m long penstock and power plant connected to the national grid by a 132 kV transmission line leading to Namsan s/s. The distance between the dam and the point where the tailrace return the water to the river is 2.2 km. The plant factor of this power plant is relatively high at 80%. The power plant would be connected to Namsan s/s by a 119 km long 132 kV transmission line.

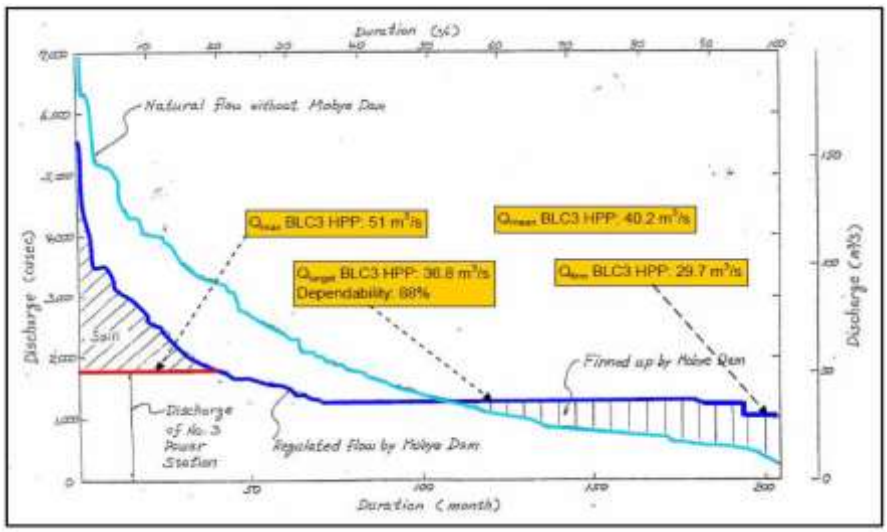
Upper Keng Tawng: The 51 MW Upper Keng Tawng HPP is under construction upstream of the existing Keng Tawng power plant, and is scheduled for completion in 2019. It will have a 56 m high rock fill dam diverting the water to a 526 m long headrace tunnel, followed by a 337 m long penstock leading to a semi underground powerhouse. The power plant will be connected to the Namsan s/s via a 132 kV transmission line.[84] This is also a storage facility (~9 days retention period). The Norwegian Government is assisting the sustainable development of the project through the Sustainable Framework for Hydropower Development in Myanmar programme (In-House advisory services to DHPI for design and construction management).[85] The power plant will be connected to Namsan s/s by a 73 km long 132 kV transmission line.

5.6.5 Nam Pawn Sub-basin

The Nam Pawn rises at around 1,550 m amsl in Lai Hka, Shan State, and flows south for about 320 km before joining the Thanlwin at Hpsawng Town dropping about 1,400 m giving an average gradient of about 4.4 m/km. Its total catchment area is 19,390 km^2 and the average flow is about 380 m^3/s.

Its largest tributary, the Baluchaung, joins the Nam Pawn from the west about 85 km upstream of the confluence with the Thanlwin. The Baluchaung has a catchment area of 7,833 km^2. The Baluchaung is regulated by one large lake (Inle Lake) and one large reservoir (Mobye).

Figure 5.16: Flow duration curve Baluchaung



Source: EIA and SIA for Baluchaung 3 Hydropower Project, February 2011

[82] Retention period estimated at 3.6 days assuming catchment area is about 8,450 km^2 and inflows similar to Nam Paw flows (19.5 l/s/km^2) and live storage of 52 hm^3.

[83] GE shows that about 7 km upstream of the dam site, the Nam Teng splits into two branches. The branches again join about 1.3 km downstream of the Keng Tawng tailrace. The dam is on the right hand branch, which in Figure 5.5 shows to be disconnected from the Nam Teng River. They should be joined at the top.

[84] Through visual inspection in GE and applying the TWL 695m, the correct coordinates for this site appears to be 20.74558°N 98.184077°E. GE shows a dam under construction at this site. Coordinates provided by MoEE 20.752128°N 98.106276°E are likely not to be correct.

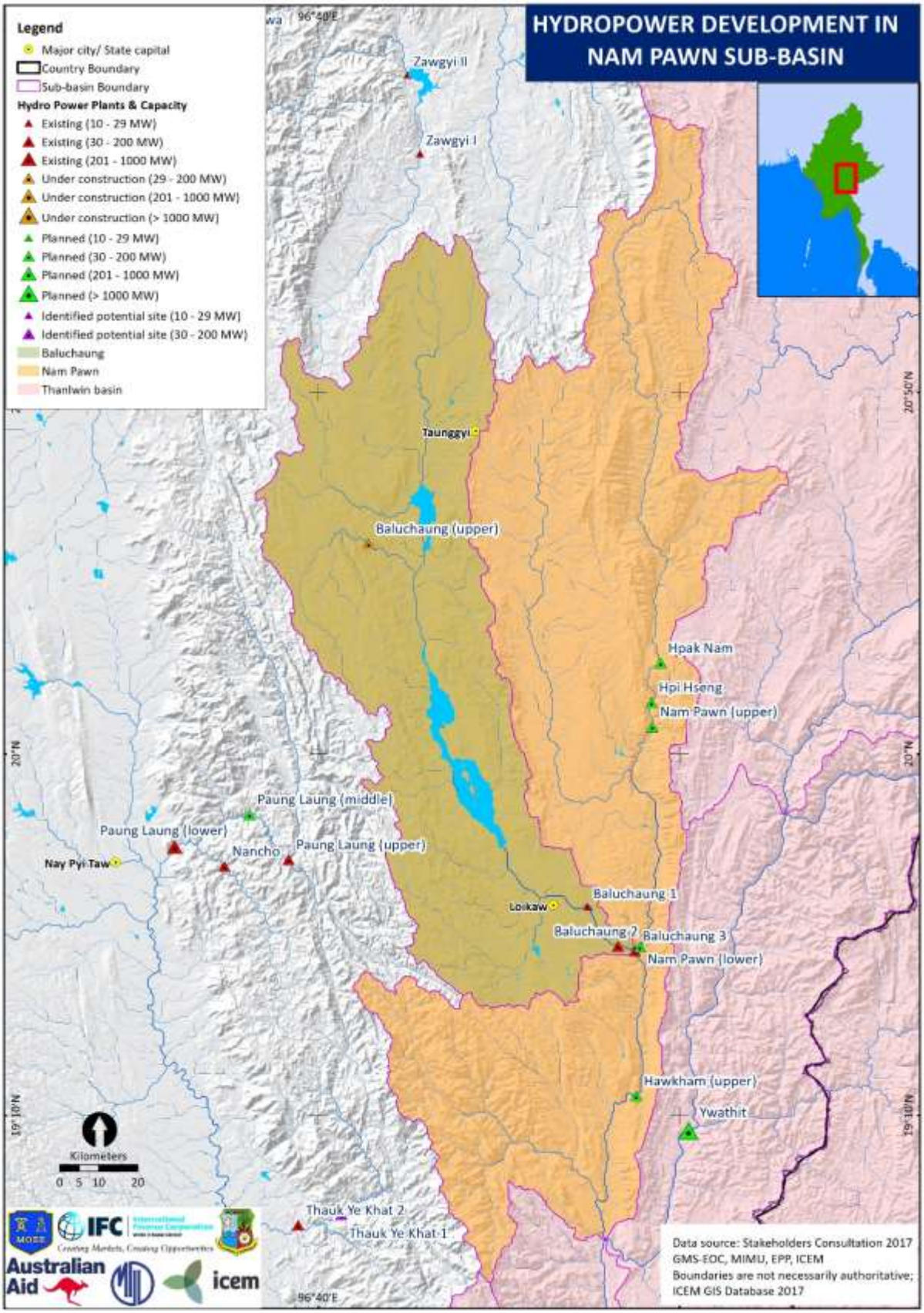
[85] http://spectrumsdkn.org/en/library/myanmar-s-energy-future/260-sustainable-framework-for-hydropower-development-in-myanmar/file

Inle Lake: The upstream Inle Lake has a surface area of about 116 km^2, but it is not very deep. Average depth is 2.1 m with the deepest point being 3.7 m. The Inle Lake drains at its southern end into the Baluchaung, which flows for about 35 km before entering the Mobye Reservoir.

Mobye reservoir: the 11 m high Mobye dam on the Baluchaung in Kayah State at el 880 m amsl creating the reservoir that was constructed (1967 - 1971) under a bilateral war reparation agreement between Japan and the then Burmese Government. The dam stores 827 hm^3 of water in a 207 km^2 reservoir for the downstream Lawpita River (now called Baluchaung) hydropower cascade complex and for irrigation of downstream agricultural land on either side of the Baluchaung. The dam supplies water to the Baluchaung I-III HPPs.

The catchment area at the Mobye dam is 6,221 km^2. The dam has altered the natural flows in the Baluchaung as shown in the flow duration curves for flows without Mobye dam and the outflow from Mobye dam in Figure 5.16. The curves show how river flows in the rainy season are stored and released in the dry season increasing firm flow from 5-10 m^3/s to 29.7 m^3/s, thus allowing a continuous power generation at the downstream power plants in the dry season. The Mobye dam and the three relatively low intake dams of the Baluchaung hydropower cascade disturbed the natural outflows from Inle Lake upstream for a distance of about 119 km from the uppermost end of Mobye reservoir to the confluence of the Baluchaung with the Nam Pawn. Both intake dams for Baluchaung 1 and 2 are gated, although Baluchaung 2 intake is not generally used.

Figure 5.17: Hydropower development in Nam Pawn Sub-basin



5.6.5.1 Nam Pawn

MoEE and Trust Energy Investments Pte. Ltd. (TEI)[86] with HTCT Energy Investment Company Ltd. (HCTC) signed a MoU[87] in October 2015 for the development of five hydropower plants in the Nam Pawn. These projects consist of the 103 MW **Hpak Nam**, the 48 MW **Hpyi Hseng**, the 140 MW **Upper Nam Pawn**, the 147 MW **Lower Nam Pawn** and the 139 MW **Haw Hkam**. The projects are still at pre-feasibility stage, but initial analysis indicates that the Lower Nam Pawn and Haw Hkam are not viable for geological reasons, and the existence of a new bridge in one of the proposed reservoir areas. The Lower Nam Pawn reservoir would also severely impact several villages, which would result in excessive costs to mitigate.

Table 5.47: Nam Pawn - Proposed Project Data

Project	Installed Capacity (MW)	Generation (GWh/yr)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Reservoir length (km)	Distance dam to power house (km)	Export (%)
Hpak Nam	105	NP	20	20	NP	NP	ROR	<1	7.0	0%
Hpiy Seng	45	NP	10	4	NP	NP	ROR	<1	8.0	0%
Nam Pawn (upper)	150	NP	10	7	NP	NP	ROR	<1	14.0	0%
Nam Pawn (lower)	105	NP	88	526	NP	NP	NP	36	-	0%
Hawkham	180	NP	72	333	NP	NP	NP	29	-	0%
	585	**~2,716**	**10-88**	**890**	**-**			**67**	**29.0**	**0%**

(NP): Not provided; (+) ROR: run of river, S: storage

Table 5.48: Nam Pawn - Proposed Project Development Status

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Scheduled for
Hpak Nam	(*)	MoU	27/10/15	TEI	HTCT	Singapore	2020
Hpi Seng	(*)	MoU	27/10/15	TEI	HTCT	Singapore	2020
Hawkham	(*)	MoU	27/10/15	TEI	HTCT	Singapore	2020
Nam Pawn (lower)	(*)	MoU	27/10/15	TEI	HTCT	Singapore	2020
Nam Pawn (upper)	(*)	MoU	27/10/15	TEI	HTCT	Singapore	2020

(*): Not yet applicable as projects are still undergoing pre-feasibility study.

The three remaining upstream projects are proposed to be built in a relatively narrow and deep gorge where the river drops about 580 m over a distance of 34 km, providing a steep average gradient of 17 m/km. Availability of flows is low, estimated at about 20 $l/s/km^2$, a third to a quarter of flows in the Ayeyarwady Headwaters. The three intakes would consist of 10-20 m high dams, each diverting water to headrace tunnels leading to their respective penstocks and powerhouses. If no environmental flow is allowed for, much of the 34 km of the riverbed could be relatively dry during part of the year. These projects are earmarked for domestic power supply only. It is unlikely they will be commissioned by 2020.

[86] According to MoEE, Kansai Electric Power Company (KEPCO), a Japanese electricity utility, is assisting the developers preparing the projects.

[87] The MoU validity is 34 months, with a preliminary assessment of the proposed Haw Kham hydropower project due within 18 months.

5.6.5.2 Baluchaung Watershed

There are three existing and one under construction HPPs above 10 MW capacity in the Baluchaung watershed, a tributary of the Nam Pawn (Table 5.48), all within Loikaw Township, Kayah State.

Table 5.49: Baluchaung River - Power Plant Characteristics

Power Plant	Stage (*)	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Baluchaung I	E	28	200	11	2.0	0	0.2	10.3	MoEE	1992
Baluchaung II	E	168	1,190	-	-	-	-	7.1	MoEE	1974
Baluchaung III	E	52	334	i	-	-	-	5.1	Future Energy	2014
Upper Baluchaung	C	30	90	35	2.2	9.7	NP	3.0	NeoEnergy Oasis	2020
Sum		**278**	**1,814**	**0 - 35**	**4.2**	**9.7**	**>0.2**	**25.5**		

(*): "E": Existing, "C": under construction

Baluchaung I: the 28 MW Baluchaung I hydropower plant located immediately upstream of the Baluchaung II intake, was completed in 1992. This run-of-river hydropower facility consists of an 11 m gated diversion weir, a 7.45 km long headrace canal, a head-pond, a 2.2 km long penstock and an above-ground powerhouse with two 14 MW Francis generating units. The power plant is operated by MoEE generating on average 200 GWh/year at a high plant factor of 82%. It will soon undergo rehabilitation funded by Japanese ODA.

Baluchaung II: construction of the 168 MW Baluchaung II HPP (previously named Lawpita HPP), the first large-scale hydropower plant in the country, started in 1954 and was completed in 1974. The power plant takes advantage of the Lawpita Falls, providing a turbine head of 422 m. The first phase of three generating units totalling 84 MW was completed in 1960, with the second phase of a further three generating units totalling 84 MW commissioned in 1974. It has recently been rehabilitated under Japanese ODA funds. MoEE operates the power plant.

Baluchaung III: the third power plant in the cascade, the 52 MW Baluchaung III, was completed in 2014. The power plant discharges into the Nam Pawn a short distance downstream of the confluence with the Baluchaung. Future Energy, a member of the Shwe Taung Group, privately owns this project.

Baluchaung I-III operate practically on the same river flow since water discharged from the Baluchaung I turbines directly enters the Baluchaung II headrace with virtually no intermediate catchment inflow, and Baluchaung II directly discharges water into the Baluchaung III headrace. The power plants are therefore in practice operated as one. When the central power dispatcher instructs to increase or decrease power from the Baluchaung system, all three power plants need to adjust their operation proportionally. The cascade utilizes a combined elevation difference of 650 m and generates on average about 1,724 GWh/year, transmitted through two 220 kV transmission lines to Yangon and Swemyo respectively, a 132 kV transmission line to Mandalay, and a 33 kV distribution line to Loikaw and the surrounding area.

Upper Baluchaung: the 30 MW Upper Baluchaung is under construction in the upper reaches of the Baluchaung upstream of Mobye Dam, scheduled for completion in 2019. It has a 35 m high dam, which will create a reservoir that will inundate 10 km^2 and store 2.2 hm^3. A 2.6 km long headrace canal will lead to a penstock 266 m long connecting to two Francis turbines in an above ground power house. A 32 km 66 kV transmission line will connect the power plant to the Kalaw s/s.

5.7 Sittaung Basin

The Sittaung originates in the northeast of Yamethin on the edge of Shan Plateau in south central Myanmar. It is 420 km long and has a basin of 48,100 km^2. It has a mean annual flow of about 1,540 m^3/s (equivalent to a unit flow of 32 $l/s/km^2$) at its mouth in the Bay of Martaban. The river is navigable for 40 km year round and 90 km during three months in the monsoon.[88] There are seven tributaries to the Sittaung on which there are nine dams with large hydropower plants, plus several irrigation dams.

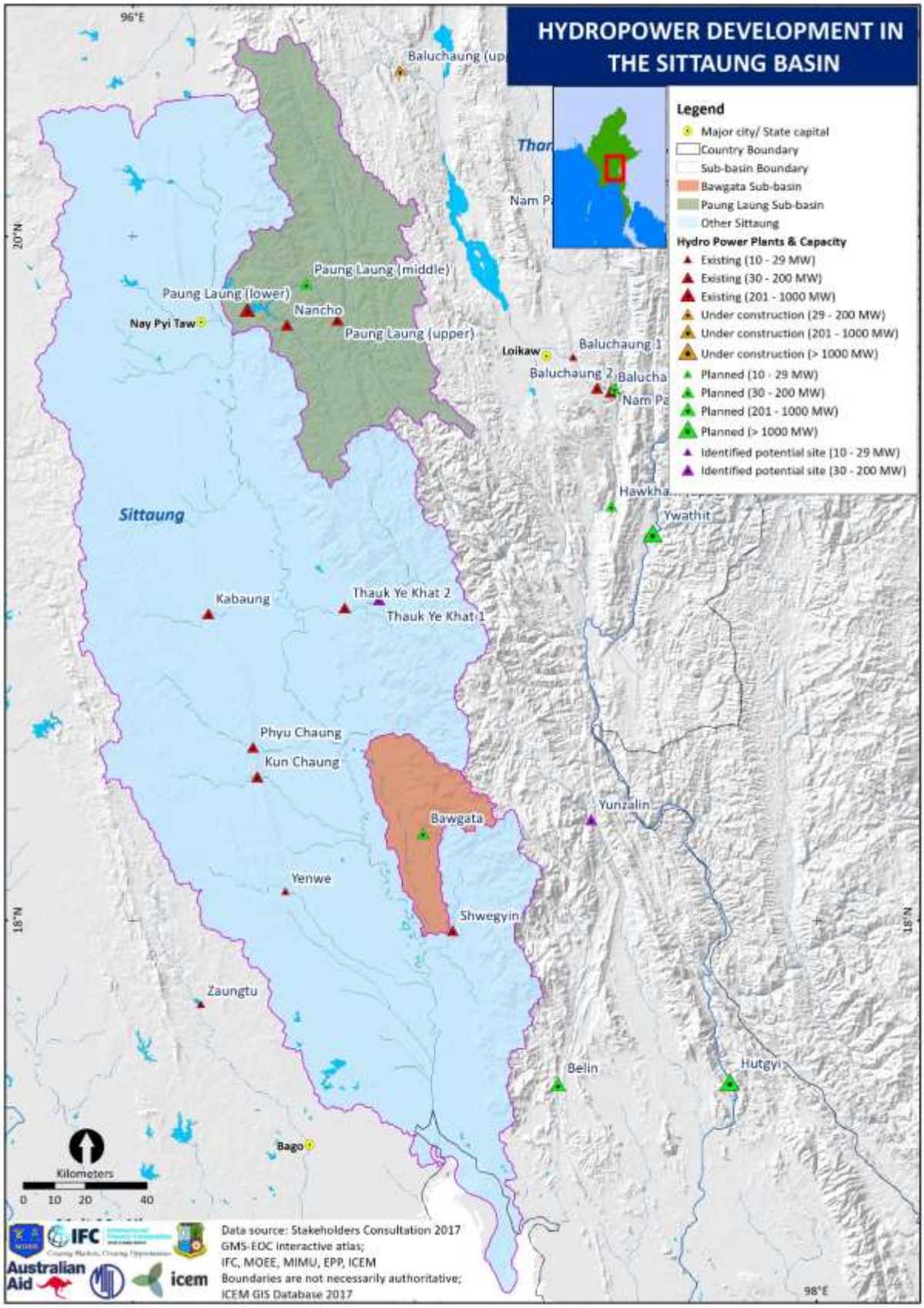
The nine hydropower plants in the Basin have an installed capacity of 810 MW. Two more projects are planned with an installed capacity of 260 MW.

Table 5.50: Sittaung Basin - Hydropower Development (>10 MW)

Sub-Basin/River	No. Power Plants	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Inundated Area (km^2)	Reservoir Length (km)
Existing and under construction	9	810	2,936	61-94	8,213	538	>69
Planned	2	260	842	80-83	1,264	29	NP
Sum	**11**	**1,070**	**3,778**	**61-94**	**9,477**	**567**	**>69**

[88] https://sites.google.com/site/bagosittaungriverbasinanalysis/system-discription/a-phy/i-location-dimensions

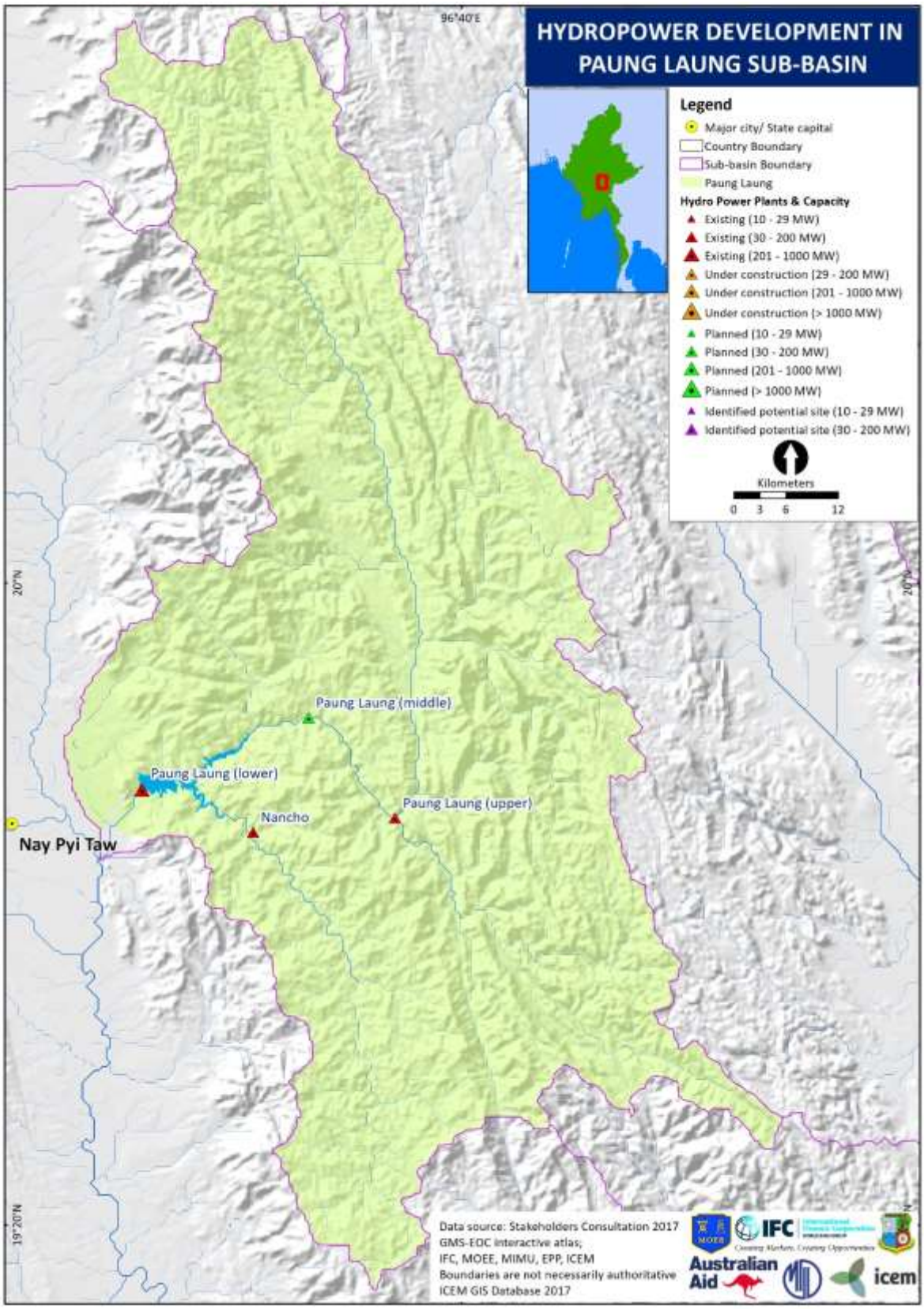
Figure 5.18: Sittaung Basin hydropower development



5.7.1 Paung Laung Sub-basin

The Paung Laung River has the largest catchment area among the Sittaung tributaries at 4,987 km^2. Figure 5.19 shows the location of the existing power plants and proposed projects.

Figure 5.19: Hydropower development in Paung Laung Sub-basin



5.7.1.1 Existing and Under Construction HPPs

There are three existing multipurpose facilities which prime purpose is hydroelectric generation in the Paung Laung Sub-basin. The total installed capacity is 460 MW and the three power plants have created reservoirs that inundate 26 km^2 and store 1,973 hm^3. The total length of the reservoirs is 69 km. MoEE operates the three power plants. Table 5.51 shows the characteristics of each plant.

Table 5.51: Paung Laung Sub-basin - Existing Power Plants

Power Plant	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Paung Laung (U)	140	454	98	1,286	11	50	-	MoEE	2015
Nancho	40	152	72	9	0	3	5.2	MoEE	2014
Paung Laung (L)	280	911	131	678	15	16	-	MoEE	2005
	460	**1,517**	**72 - 131**	**1,973**	**26**	**69**	**5.2**		

Upper Paung Laung: The 140 MW Upper Paung Laung HPP about 40 km upstream of the Lower Paung Laung dam was completed in 2015 after ten years construction. The 98 m high RCC dam has the largest reservoir in the cascade storing 1,286 hm^3 and extending 50 km. The large reservoir will allow the river to be regulated to improve generation at Lower Paung Laung and increase the irrigation potential further downstream. The above ground power plant is connected to the Lower Paung Laung switchyard via the Nancho HPP by a 27 km long (to Nancho) 230 kV transmission line.

Nancho: The 40 MW Nacho HPP completed in 2014 discharges into the Lower Paung Laung reservoir. Its 72 m high dam creates a relatively small reservoir that inundates 0.3 km^2 and stores 9 hm^3. It diverts water along a 2.36 km long headrace tunnel to a head pond and then 220 m long penstock. The above ground power plant about 5.2 km downstream of the dam is connected to the Lower Paung Laung switchyard by a 12.5 km long 230 kV transmission line.

Lower Paung Laung: The 280 MW Lower Paung Laung HPP completed in 2005 about 20 km East of Nay Pyi Taw has the highest dam in the Sub-basin (131 m). Its underground power plant close to the toe of the spillway comprises four 70 MW Francis generating units. The reservoir inundates 15 km^2 and stores 678 hm^3. It is a multipurpose dam, which primary purpose is hydroelectric power generation, but also serves irrigated agriculture by providing water to an irrigation weir about 14 km downstream. The power plant was funded by PRC at a cost of $201.8 million. A 13 km double-circuit 230 kV connects the power plant to the Pyinmana s/s.

5.7.1.2 Planned Hydropower Project

One hydropower plant is planned for the Paung Laung Sub-basin.

Table 5.52: Paung Laung Sub-basin - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Export
Middle Paung Laung	100	342	83	429	10	29	S	0%

(+) S: storage reservoir

Table 5.53: Paung Laung Sub-basin - Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Middle Paung Laung	n.a.	MoU	21/10/15	Energized Myanmar	-	SIN	2021

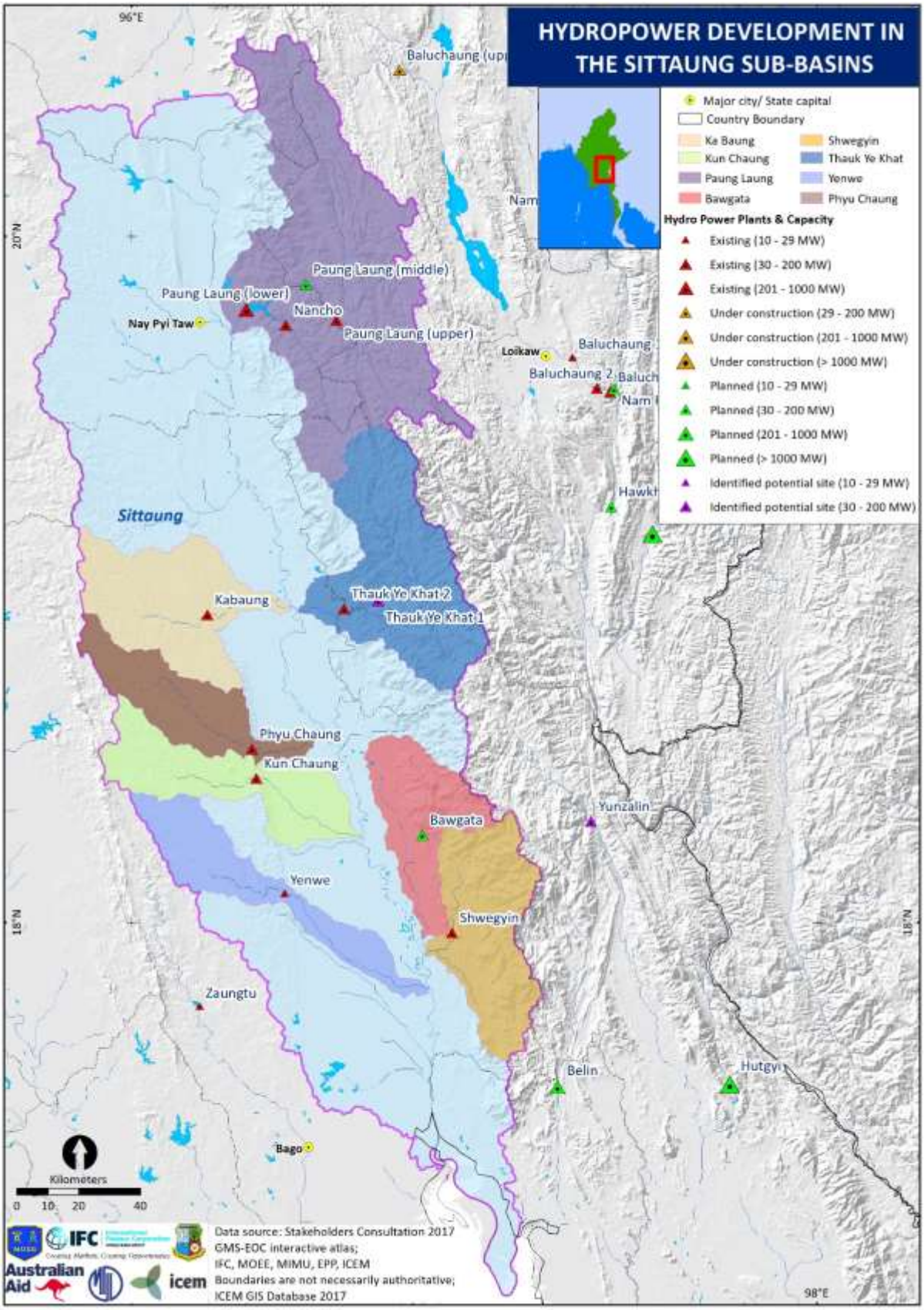
Middle Paung Laung: The Middle Paung Laung about 22 km upstream of the Lower Paung Laung dam is earmarked for JV BOT arrangement. MoEE and Energized Myanmar signed a MoU on 21 October 2015 to implement a 100 MW project with a 110 m high RCC dam. It is at the feasibility study stage. Once this project has been completed, the total storage in the cascade will amount to 2,405 hm^3, of which 1,454 hm^3 (60%) will be live storage further increasing regulation and increasing power generation at Lower Paung Laung and irrigation potential. The power plant would be connected to Baluchaung - Shweymyo transmission line by an 8 km long double circuit 230 kV transmission line.

5.7.2 Other Sittaung Sub-basins

There are six rivers in the Sittaung Basin in addition to the Paung Laung that have multipurpose facilities comprising hydropower plants larger than 10 MW, and one with one project planned. The rivers are:

- Ka Baung Chaung (1,783 km^2)
- Thauk Ye Khat (2,461 km^2)
- Phyu Chaung (1,176 km^2)
- Kun Chaung (1,498 km^2)
- Shwegyin (1,759 km^2)
- Ye Nwe (1,267 km^2)
- Bawgata (1,229 km^2)

Figure 5.20: Hydropower development in other Sittaung Sub-basins



5.7.2.1 Existing and Under Construction HPPs

Six hydropower and multipurpose dams have been built between 2007 and 2015 on six tributaries to the Sittaung with a total installed capacity of 350 MW, inundating 512 km^2 and storing 6,240 hm^3. (Table 5.53).

Table 5.54: Other Sittaung Sub-basins - Existing Hydropower Plants (>10 MW)

River	Power Plant	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Distance dam to power-house (km)	Developer	Year
Ka Baung Chaung	Ka Baung	30	120	61	1,468	~150	-	MoEE/ MOALI	2008
Thauk Ye Khat	Thauk Ye Khat 2	120	604	94	444	60	-	Gold Energy (MYA)	2014
Phyu Chaung	Phyu Chaung	40	120	75	780	16	-	MoEE/ MOALI	2015
Kun Chaung	Kun Chaung	60	190	73	1,468	~150	2.9	MoEE	2012
Shwegyin	Shwegyin	75	262	57	2,080	59	-	MoEE	2011
Ye Nwe	Ye Nwe	25	123	77	NP	77	-	MoEE/ MOALI	2007
		350	**1,419**	**57 - 94**	**> 6,240**	**>512**	**2.9**		

Ka Baung: The Ka Baung multipurpose facility in Oak Twin Township, Bago Region, completed in 2008 and operated by MoEE and MoALI comprises a 30 MW power plant. Its 61 m high dam has created a reservoir inundating[89] 150 km^2 and storing 1,468 hm^3, of which 26% is live storage. Water released by the facility is diverted for irrigation at an irrigation weir about 11 km downstream (one outlet in each bank). A 25 km long double-circuit 33 kV transmission line connects the power plant to Taungoo s/s.

Thauk Ye Khat 2: Only one power plant, the 120 MW Thauk Ye Khat (2) in Taungoo Township, Kayin State, has been built by the private sector (Gold Energy) under a BOT arrangement in the Sittaung Basin purely for hydroelectric generation. Its 94 m high earth dam has created a reservoir that inundates 60 km^2 and stores 444 hm^3. The power plant is connected to Taungoo s/s by a 230 kV transmission line.

Phyu Chaung: The Phyu Chaung multipurpose facility in Phyu Township, Bago Region, completed in 2015 and operated by MoEE and MoALI comprises a 40 MW power plant. Its 75 m high rock-fill dam has created a reservoir inundating 16 km^2 and storing 780 hm^3, of which 93% is live storage. Water released by the facility is diverted for irrigation at an irrigation weir about 4 km downstream (one outlet in each bank). An 8 km long 33 kV transmission line connects the power plant to Taungoo s/s.

Kun Chaung: The Kun Chaung hydropower plant in Phyu Township, Bago Region, completed in 2012 and operated by MoEE comprises a 60 MW power plant. Its 75 m high rock-fill dam has created a reservoir inundating[90] 150 km^2 and storing 1,468 hm^3, of which 77% is live storage. The 2,125 m long headrace tunnel brings the water to the aboveground powerhouse 2.9 km downstream of the dam. Water released by the facility is diverted for irrigation at an irrigation weir about 4 km

[89] The 150 km^2 is a preliminary approximation to the reservoir area measured in GoogleEarth because the cauliflower shape of the reservoir makes it difficult to measure the area accurately.

[90] The 150 km^2 is a preliminary approximation to the reservoir area measured in GoogleEarth because the cauliflower shape of the reservoir makes it difficult to measure the area accurately.

downstream (one outlet in each bank). A 41 km long 33 kV transmission line connects the power plant to Chauk s/s.

Phyu Chaung: The Phyu Chaung hydropower plant in Phyu Township, Bago Region, completed in 2011 and operated by MoEE comprises a 40 MW power plant. Its 75 m high rock-fill dam has created a reservoir inundating 24 km^2 and storing 2,080 hm^3, of which 70% is live storage. A 41 km long 230 kV transmission line connects the power plant to Tharyargone s/s.

Ye Nwe: The Ye Nwe multipurpose facility in Kyauktaga Township, Bago Region, completed in 2007 and operated by MoEE and MoALI comprises a 25 MW power plant. Its 77 m high earth dam has created a reservoir inundating 77 km^2. Water released by the facility is diverted for irrigation at an irrigation weir about 12 km downstream (one outlet at the left hand bank). A 27 km long double-circuit 33 kV transmission line connects the power plant to Tharyargone s/s.

5.7.2.2 Planned Hydropower Project

The Bawgata project is planned for construction in the Sittaung River Basin outside the Paung Laung sub-basin.

Table 5.55: Other Sittaung Sub-basins - Planned Projects - Key Data

River	Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Export
Bawgata	Bawgata	160	500	80	835	19	NP		0%
Thauk Ye Khat	Thauk Ye Khat 1[91]	150	NP	NP	NP	NP	NP		0%
	Sum	**310**	**>500**	**>80**	**>835**	**>19**			

(+) S: storage reservoir; (NP) No data

Table 5.56: Other Sittaung Sub-basins - Planned Projects - Development Process

River	Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Developer	Year
Bawgata	Bawgata	n.a.	Local MoU	18/02/16	-	Thoolei	Thoolei	2020

Bawgata: The 160 MW Bawgata HPP in Kyauk Gyi Township, Bago Region, will be the second private sector project to be developed in the Sittaung Basin. In 2014, the Norwegian Government provided assistance to support the peace building efforts in Myanmar through a prefeasibility study adopting international best practice in hydropower development. This includes extensive consultations with representative of local communities, in this case the Karen National Union, and people to be affected by the project. MoEE and Thoolei signed a local MoU on 18 February 2016 for the project to be developed under the BOT arrangement purely for hydroelectric generation. Its proposed 80 m high rock fill dam will create a reservoir that inundates 19 km^2 and stores 835 hm^3. The project is scheduled to be completed by 2021, which seems optimistic.

[91] This 150 MW proposed project upstream of Thauk Ye Khat 2 has only been identified as a potential hydropower site. No specific data is available to the SEA Team

5.8 Mekong basin

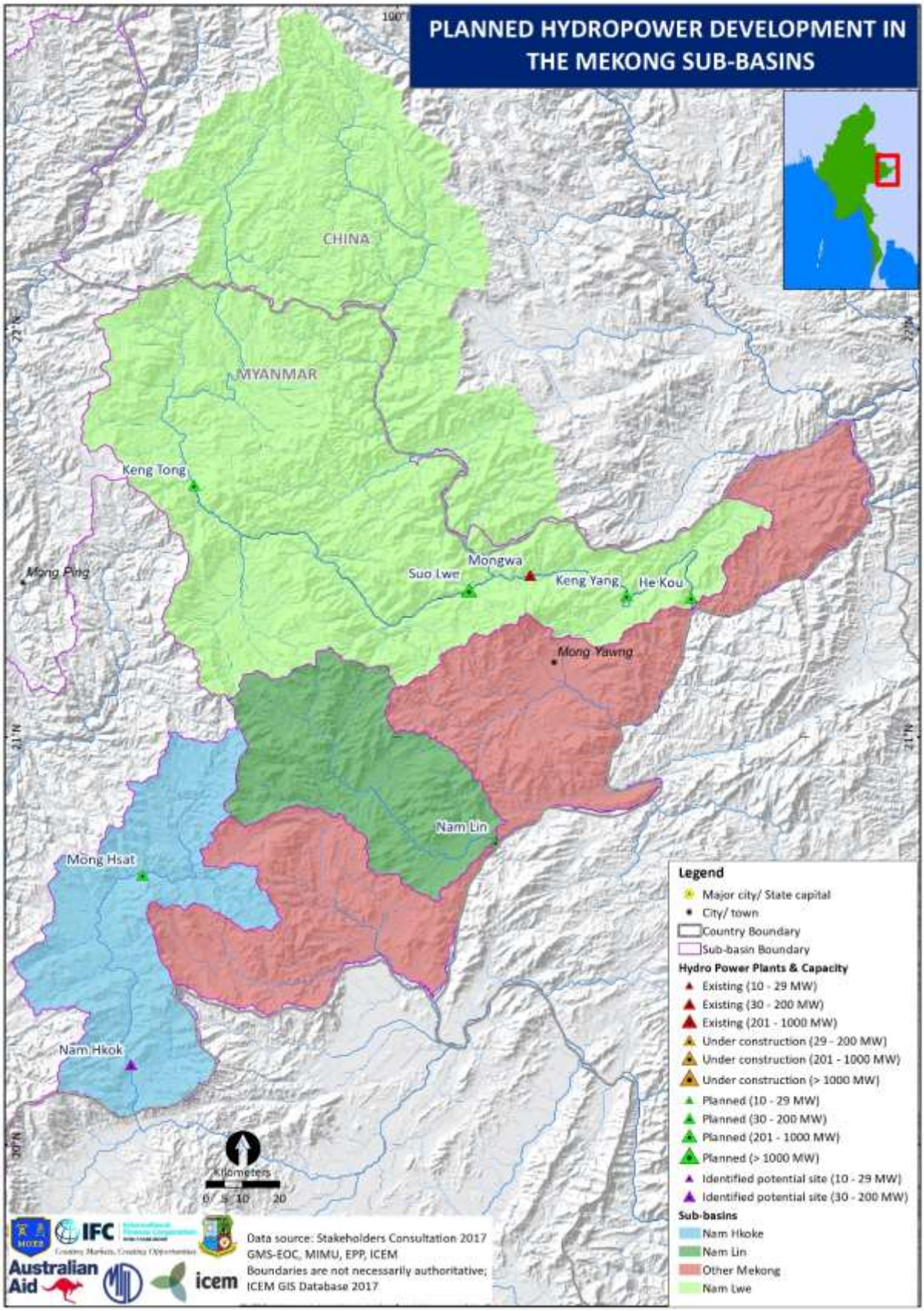
There are three tributaries to the Mekong that have identified hydropower potential within Myanmar territory: the Nam Lwe, the Nam Lin and the Nam Hkoke.

The Nam Lwe rises in PRC and flows into Shan State where Road S309 crosses the border near the town of Mangxienzhen, PRC. It flows for 326 km through Myanmar territory before discharging into the Mekong River at Su Lei checkpoint harbour at the border with Lao PDR. The catchment area is 15,209 km^2, and unit flow is about 24 l/s/km^2 resulting in a discharge into the Mekong of 365 m^3/s.

The Nam Lin, to the south of the Nam Lwe, rises in Keng Tung Township, Shan State at an elevation of about 1,500 m. At its confluence with the Mekong, the catchment area is 2,614 km^2 and the mean annual flow about 46 m^3/s.

The Nam Hkoke rises in Keng Tung Township, Shan State at an elevation of about 1,200 m and flows south through Mong Hsat Township where it crosses the border into Thailand and joins a tributary to the Mekong. At the border, the catchment area is 3,380 km^2 and mean annual flow about 50 m^3/s.

Figure 5.21: Mekong basin - Hydropower development in Myanmar



5.8.1 Nam Lwe sub-basin

Figure 5.21 shows the location of the identified dams on the Nam Lwe as well as the adjusted locations of Mongwa Keng Yang[92] and Suo Lwe.[93]

5.8.1.1 Existing and Under Construction HPPs

Table 5.57: Nam Lwe Sub-basin - Existing Power Plant

Power Plant	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Mongwa	66	331	51	78	8	31	-	SSED	

Mongwa: MoEE signed a Covenant on 22 March 2016 with the Shan State East Development Company under a BOT arrangement to implement the 66 MW Mongwa HPP on the Nam Lwe in Kengtung District,[94] Shan State. The project has a 51 m high dam that created a reservoir inundating 8 km^2 and storing 78 hm^3. It was completed in early 2017.

5.8.1.2 Planned Hydropower Project

On 25 September 2007, MoEE and YNIC signed a MoU to develop four projects: **Keng Tong** (170 MW), **Suo Lwe** (240 MW), **Keng Yang** (70 MW) and **He Kou** (138 MW).[95] The feasibility studies were submitted to MoEE on 8 June 2011, and on 27 January 2015 MoEE and YNIC signed an official agreement on transfer of hydropower development rights of the Nam Hka and Nam Lwe Rivers to Yunnan Power Grid Co. Ltd. [96] The projects are scheduled for completion in 2025-26. No information was made available on whether or not EIAs have been submitted to MONREC.

Table 5.58: Nam Lwe Sub-basin - Planned Projects - Key data

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Retention period (days)	Type (*)	Reservoir Area (km^2)	Reservoir Length (km)	Export (%)
Keng Tong	170	536	NP	32	1.2	ROR	8.4	26.0	NP
Suo Lwe	240	NP	NP	1,338	46.4	S	40.9	72.0	NP
Keng Yang	70	155	NP	41	0.3	ROR	5.4	24.0	NP
He Kou	138	483	NP	68	0.4	ROR	6.5	27.0	NP
	618	**1,174**		**1,479**			**61.2**	**149**	

(*) ROR: run of river, S: storage; (NP): No data

[92] When plotting the location of the projects in GE we found some anomalies that needed to be checked. The location of Mongwa does not seem correct since the elevation of the river at the given coordinates is el.794 m in GE. The FSL of the reservoir is at el. 555 m, i.e. the project should be located further downstream. At the location where the river elevation is around 530 m in GE taking into account the height of the dam, the satellite imagery shows a dam under construction. If this is Mongwa, then the coordinates provided for Keng Yang are also not correct since both catchment area and mean annual flow at this site is larger than at Mongwa, i.e. Keng Yang must be downstream of Mongwa, possibly at a location with coordinates about N21.3469° E100.5619°. The river elevation at this site is about 506 m.

[93] The coordinates of Suo Lwe provide to the SEA Team are not correct as they locate the project on a field west of the Nam Lin Sub-basin about 50 km away from the Nam Lwe. We have adjusted the location based on catchment area considerations.

[94] On adjusting the location to where the construction of a dam has been observed in GE, the township seems to be Mong Ywang

[95] Earlier studies had identified the 25 Wan Ta Ping in the Nam Lwe sub-basin. The SEA Team does not have nay information on this project.

[96] http://www.ynic.csg.cn/en/Major_Events/201606/t20160612_399.html

Table 5.59: Nam Lwe Sub-basin - Planned Project - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Partner	Country of Foreign Developer	Year
Keng Tong	-	MoU	25/9/07	YNIC	-	PRC	2025
Suo Lwe	-	MoU	25/9/07	YNIC	-	PRC	2025
Keng Yang	-	MoU	25/9/07	YNIC	-	PRC	2025
He Kou	-	MoU	25/9/07	YNIC	-	PRC	2025

5.8.2 Nam Lin sub-basin

Nam Lin: MoEE and MAM signed on 8 October 2015 a local MoU for the 36 MW run of river Nam Lin hydropower project to be developed as a BOT.[97] MoEE has already approved the feasibility study. The power plant would be connected to Namsan s/s by a 119 km long 132 kV transmission line.

Table 5.60: Nam Lin Sub-basin - Planned Projects - Key data

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Retention period (days)	Type (*)	Reservoir Area (km^2)	Reservoir Length (km)	Export (%)
Nam Lin	36	156	26	14	3	ROR	252 (+)	NP	0%

(*) ROR: run of river, S: storage; (NP): No data; (+): seems too large

Table 5.61: Nam Lin Sub-basin - Planned Project - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Nam Lin	NP	LocMoU	8/10/15	-	MAM	-	2021

5.8.3 Nam Hkoke sub-basin

Two HPP have been proposed on the Nam Hkoke. Little information is available for any of the projects.

[97] The coordinates provided for the Nam Lin project locates it at the confluence between the Nam Lin and the Mekong on the border with Lao PDR. The project should be further upstream the Nam Lin at some distance from the confluence to avoid the flood level variations of the Mekong River. Other data about the project provided for the HP database seems suspect.

Table 5.62: Nam Hkoke Sub-basin - Planned Projects - Key data

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Retention period (days)	Type (*)	Reservoir Area (km^2)	Reservoir Length (km)	Export (%)
Mong Hsat	30	NP	NP	NP	NP	-	NP	NP	0%
Nam Hkok[98]	30	NP	NP	NP	NP	-	NP	NP	0%
Sum	**60**								

(*) ROR: run of river, S: storage; (NP): No data

Table 5.63: Nam Hkoke Sub-basin - Planned Project - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Mong Hsat	NP	LocMoU	11/11/15	-	Suntac Power Co.	MYA	NP

Mong Hsat: Suntac Power Company signed a local MoU on 11 November 2015 for the development of the 30 MW Mong Hsat hydropower project on the Nam Hkoke about 20 km northeast of Mong Hsat town. Other than the installed capacity, no other data is available at the time of writing.

5.9 Rakhine coastal basins

The Rakhine State in western Myanmar is flanked to the east by the Rakhine (Arakan) mountain range and to the west by the Bay of Bengal; in the north it borders Bangladesh. The distance between the mountain and the sea is relatively short, usually resulting in many small river basins draining high precipitation along the mountain range. The Rakhine mountains experience among the highest rainfall in the country, annual rainfall exceeding 5,000 mm (in Sandoway), compensating the small size of the catchments to provide enough flows to make hydropower development interesting.

Several rivers have been identified as having hydropower potential,[99] the most important presently being the Lemro River and the Thathay River. Four other rivers flowing into the Bay of Bengal at Rakhine State with identified hydropower potential are Saing Din Creek, Kaladan, Than Dwe and Kyein Ta Li.

The Lemro[100] rises in Matupi Township of Mindat District, Chin state and flows south for 261 km through the northern part of Rakhine State into the Bay of Bengal at Sittwe. Its catchment area is 9,990 km^2. At the Lemro project sites, the unit flow has been estimated at 62 l/s/km^2, which would result to about 619 m^3/s at the mouth of the river.

The Thahtay rises at around 850 m asml in the Rakhine Mountains within Thandwe Township. It flows northwest and then west for about 120 km before discharging into the Bay of Bengal at Shwele Town. The catchment area at the mouth of the river is 1,293 km^2. Given that rainfall is about 45% higher at this catchment than at the Lemro sites, and assuming the unit flow is about 90 l/s/km^2, the flow at the river mouth would be about 100-120 m^3/s.

[98] This 30 MW proposed project downstream of the proposed Mong Hsat HPP has only been identified as a potential hydropower site. No specific date is available to the SEA Team

[99] http://frontiermyanmar.net/en/rakhines-hydropower-pipe-dreams

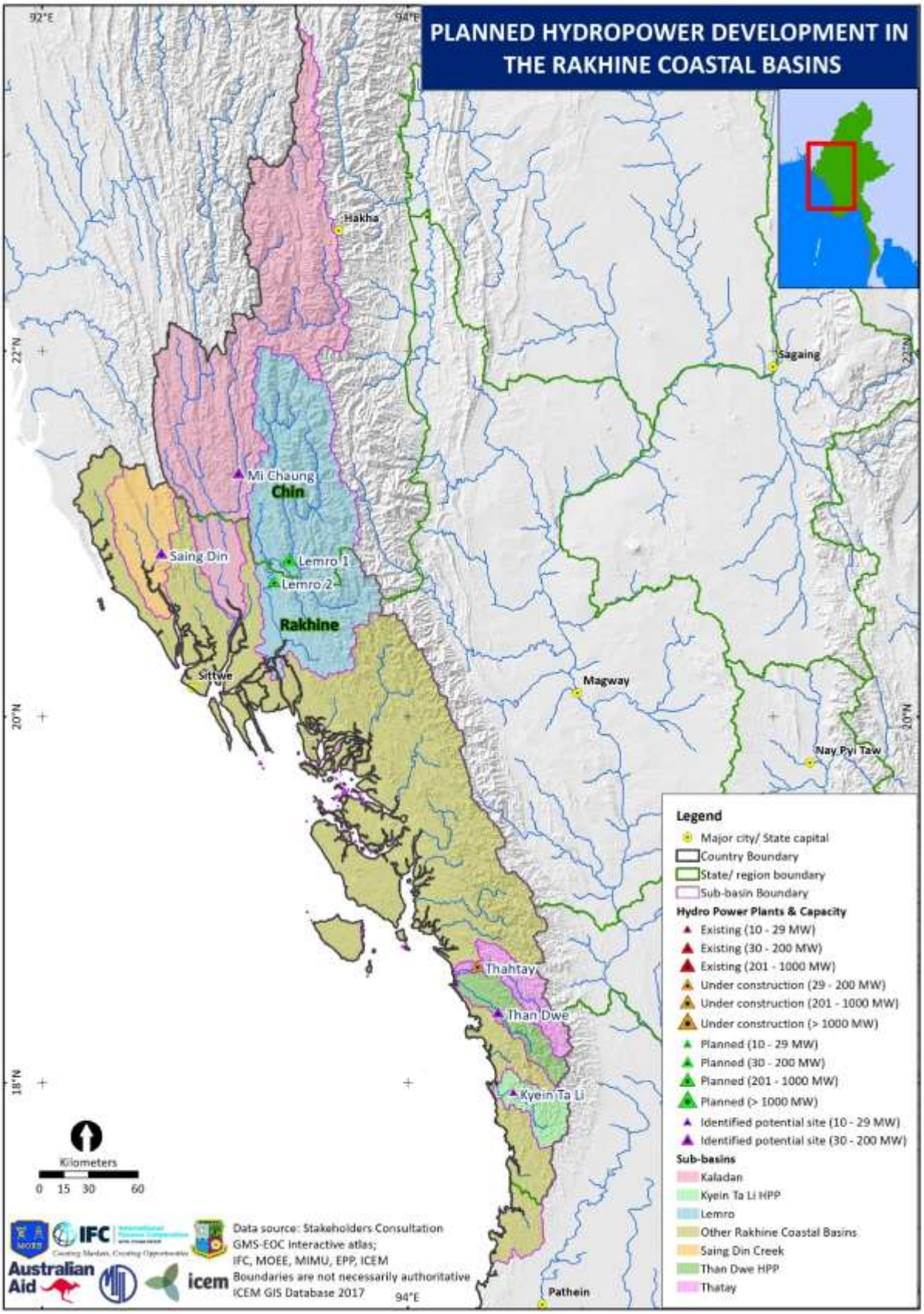
[100] Also spelled Leymo or Lay Mro

The Kaladan River (as Timit River) rises on the western flank of Mount Zinghmuh, Chin Hills in central Chin State at an elevation of 2,564 m. It forms the international border between Bangladesh and India before re-entering Myanmar and discharging into the Bay of Bengal at Sittwe. With a catchment area of 21,445 km^2 and a mean annual discharge of 3,470 m^3/s (162 $l/s/km^2$) it is the fifth largest river in the world to remain completely unfragmented by dams anywhere in its catchment. The Mi Chaung is a tributary on its left bank where there is a proposed 200 MW hydropower site. India has carried preliminary studies to develop hydropower in the Kaladan River (also known as Koladyne River) with a potential exceeding 3,500 MW.

The Than Dwe Basin runs parallel to the Thathay Basin just south of it rising about 900 m amsl in the Rakhine mountain range. It flows northwest for about 55 km before discharging into the Bay of Bengal creating a catchment area of 1,364 km^2. Mean annual rainfall over the catchment exceeds 3,000 mm/year.

The Kyein Ta Li rises close to the source of the Than Dwe River and flows first south to then turn roughly north west running about 90 km before discharging into the Bay of Bengal about 65 km south-southeast of the Than Dwe river mouth. Its catchment area is 1,065 km^2. Mean annual rainfall over the catchment exceeds 3,000 mm/year.

Figure 5.22: Hydropower development in Rakhine Coastal Basins



5.9.1 Thahtay sub-basin

One hydropower plant is under construction in the Sub-basin, the Thahtay HPP.

Table 5.64: Thahtay Sub-basin - Power plants under construction

Power Plant	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Thahtay	111	NP	91	NP	NP	NP	-	MoEE	2020

Thahtay: The 111 MW **Thathay** HPP[101] in Thandwe District is under construction by MoEE and reached almost 50% progress as of May 2017; construction started in 2008.[102] Depending on government funds, it is scheduled for completion in the 2023-24 fiscal year. It will have a 91 m rock fill high dam. The Norwegian Government is assisting the sustainable development of the project through the Sustainable Framework for Hydropower Development in Myanmar programme (improvements in handling environmental and social issues with Thahtay as a Pilot Project).[103] The power station would be connected to the Oakshitpin-Taun Gup s/s by an 8.5 km 230 kV transmission line.

5.9.2 Other Basins in Rakhine State

Little information has been provided to the SEA Team for the six proposed hydropower projects in Rakhine State totalling 1,034 MW.[104]

Table 5.65: Other Rakhine State Basins - Planned Projects - Key data

Basin	Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Retention period (days)	Type (*)	Reservoir Area (km^2)	Reservoir Length (km)	Export (%)
Lemro	Lemro 1	600	3,850	NP	NP	NP	S	229	NP	0%
	Lemro 2	90		NP	NP	NP	NP		NP	0%
Saing Din	Saing Din	77	236	NP	NP	NP	NP	NP	NP	NP
Kaladan	Mi Chaung	200	NP	NP	NP	NP	NP	NP	NP	NP
Than Dwe	Than Dwe	39	105	NP	NP	NP	NP	NP	NP	NP
Kyein Ta Li	Kyein Ta Li	28	151	NP	NP	NP	-	NP	NP	0%
	Sum	**1,034**	**>4,342**							

(*) ROR: run of river, S: storage; (NP): No data

Lemro 1 and 2: Two projects have been identified for development on the Lemro River, the 600 MW Lemro 1 and the 90 MW Lemro 2 hydropower projects. Preliminary indications show that combined they would generate 3,850 GWh/year. The combined inundation would be 229 km^2. MoEE and

[101] Also called Tha Htay Chaung
[102] http://www.mmbiztoday.com/articles/rakhine-s-tha-htay-chaung-hydro-dam-nearly-50-percent-complete
[103] http://spectrumsdkn.org/en/library/myanmar-s-energy-future/260-sustainable-framework-for-hydropower-development-in-myanmar/file
[104] Work had begun on a seventh project, the 11 MW Ann HPP in about 2014, but has since then been abandoned.

Tractabel of France signed a MoU on 12 August 2016, after which, Tractebel started the feasibility studies and hence little project information is available. Figure 5.22 shows the location of the projects.[105]

Saing Din: The project was first proposed in about 1950, but work halted in 1952. Work resumed in 1988, but was again stopped three years later. Again, it was revived in 2009, but no much progress ensued.

Mi Chaung: The 200 MW HPP would be the first and largest project in the Kaledan River. In 2007 it was being considered for export to Bangladesh, but this idea was later given up.[106]

5.10 Tanintharyi Coastal Basins

The 1,700 km long Tanintharyi mountain range[107] separates Myanmar from Thailand in southern Myanmar. The Tanintharyi Region is the southernmost region in Myanmar with an area of 43,328 km^2. The Tanintharyi River[108] is a major river in south eastern Myanmar. It rises at an altitude of 2,074 m in Dawei Township and flows into the Andaman Sea at Myeik. Rainfall in the coastal cities is high (3,921 mm at Myeik and 5,500 mm at Dawei, the Region Capital). The catchment area of the Tanintharyi basin is relatively large at 17,738 km^2 (41% of the Region). Despite its high coastal rainfall, rainfall at the proposed dam site has been estimated at 2,930 mm and the unit flow at 48 $l/s/km^2$, which may be explained by a possible rain shadow created by the mountain range between the coast and the basin, which borders Thailand.

One hydropower plant has been identified in the southern tip of Myanmar close to the border with Thailand on the Glohong Kra. The river rises at an elevation of 220 m - 250 m close to the Thai-Myanmar border and flows south-southeast for about 65 km mostly as an international border river discharging about 89 m^3/s from a drainage area of 1,585 km^2.

[105] These projects were considered for export to Bangladesh in 2007, but by around 2012 it had been given up.
[106] http://www.waterpowermagazine.com/news/newsbangladesh-unlikely-to-import-hydro-power-from-myanmar
[107] Also known as Thiokhao Tano Si in Thai and Tenasserim Range in Malay.
[108] Also known as The Great Tenasserim River

Figure 5.23: Tanintharyi Coastal Basins - Hydropower development

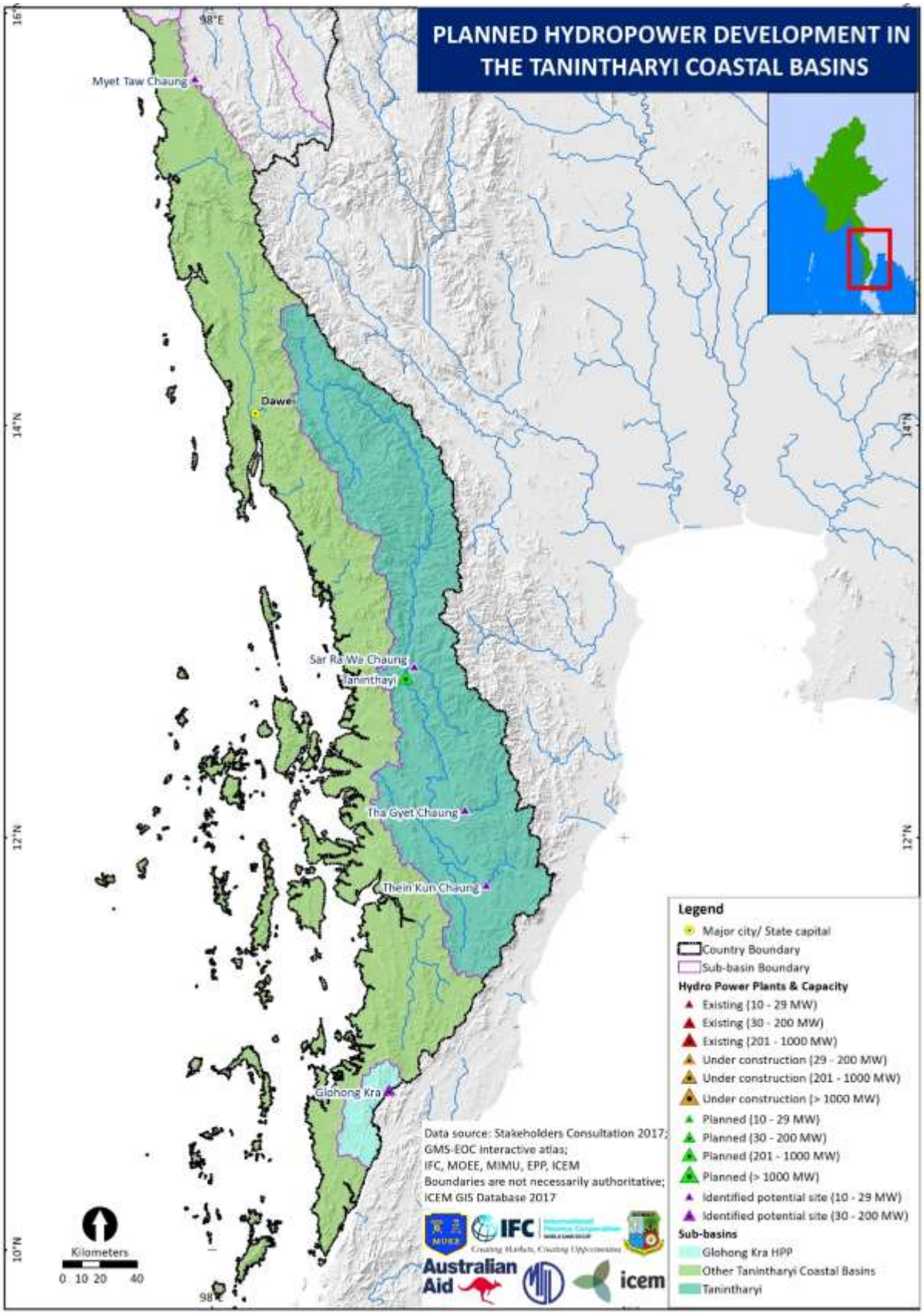


Table 5.66: Coastal Basins in Tanintharyi Region - Planned Projects - Key data[109]

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Retention period (days)	Type (*)	Reservoir Area (km^2)	Reservoir Length (km)	Export (%)
Tanintharyi	600	3,476	NP	27,086	212	S	585	NP	NP
Sar Ra Wa Chaung	11	NP	NP	NP	NP		NP	NP	
Ta Gyet Chaung	20	NP	NP	NP	NP		NP	NP	
Thein Kub Chaung	25	NP	NP	NP	NP		NP	NP	
Glohong Kra	40	NP	NP	NP	NP		NP	NP	
Sum	**696**	**>3,476**		**>27,086**			**>585**		

(*) ROR: run of river, S: storage; (NP): No data

Table 5.67: Coastal Basins in Tanintharyi Region - Planned Project - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Country of Foreign Developer	Year
Tanintharyi	-	MoU	9/10/08	Italian-Thai	-	Thailand	NP

Tanintharyi: One project has been listed in the HP Database for this region - the 600 MW Tanintharyi hydropower project. Its reservoir would inundate a large area of about 585 km^2, while the total storage is also very large at 27,086 hm^3. Italian-Thai, a Thai construction firm with experience in hydropower construction, signed a MoU with MoEE on 9 October 2008. During 2008 - 2011 Italian-Thai carried out surveys in the area, but local concerns slowed down the project. The MoU has been terminated. The power plant would have been connected to Dawei s/s by a 332 km long double-circuit 230 kV transmission line.

MoEE only provided information on installed capacity and location for the four other projects in Table 5.62. However, a quick check using GIS information indicates that the installed capacity of Glohong Kra may be overestimated.[110]

5.11 Myit Ma Ka and Bago Basin

The Bago River rises in the hills of the Pegu range and flows into the Myit Ma Ka, after which it is called the Yangon River. The basin has a catchment area of 5,348 km^2 and the main river is 331 km long. The annual rainfall is 2,980 mm, resulting in an annual average flow of 112 m^3/s. Only one hydropower plant greater than 10 MW exists in the Bago River.

[109] There are indications a further five hydropower projects are being planned in the range 10 MW to 50 MW, but the SEA team has been unable to obtain information about these projects before issuing the report.

[110] The WWF GMS database indicates that the mean annual flow at the project site at the given location by MoEE is a mere 3 m3/s for a catchment of about 60 km^2. This would result in a unit flow of about 45 $l/s/km^2$, which is the same order of magnitude as for the much larger Taninthayi HPP (48 $l/s/km^2$). Assuming the maximum turbine discharge of 1.5 times the mean annual flow, the necessary head to generate 40 MW would be about 1,000 m. Considering that the river rises at about 220 – 250 m amsl, and even if the flows were to be doubled, then this is not plausible.

Figure 5.24: Myit Ma Ka & Bago basin and Bilin basin

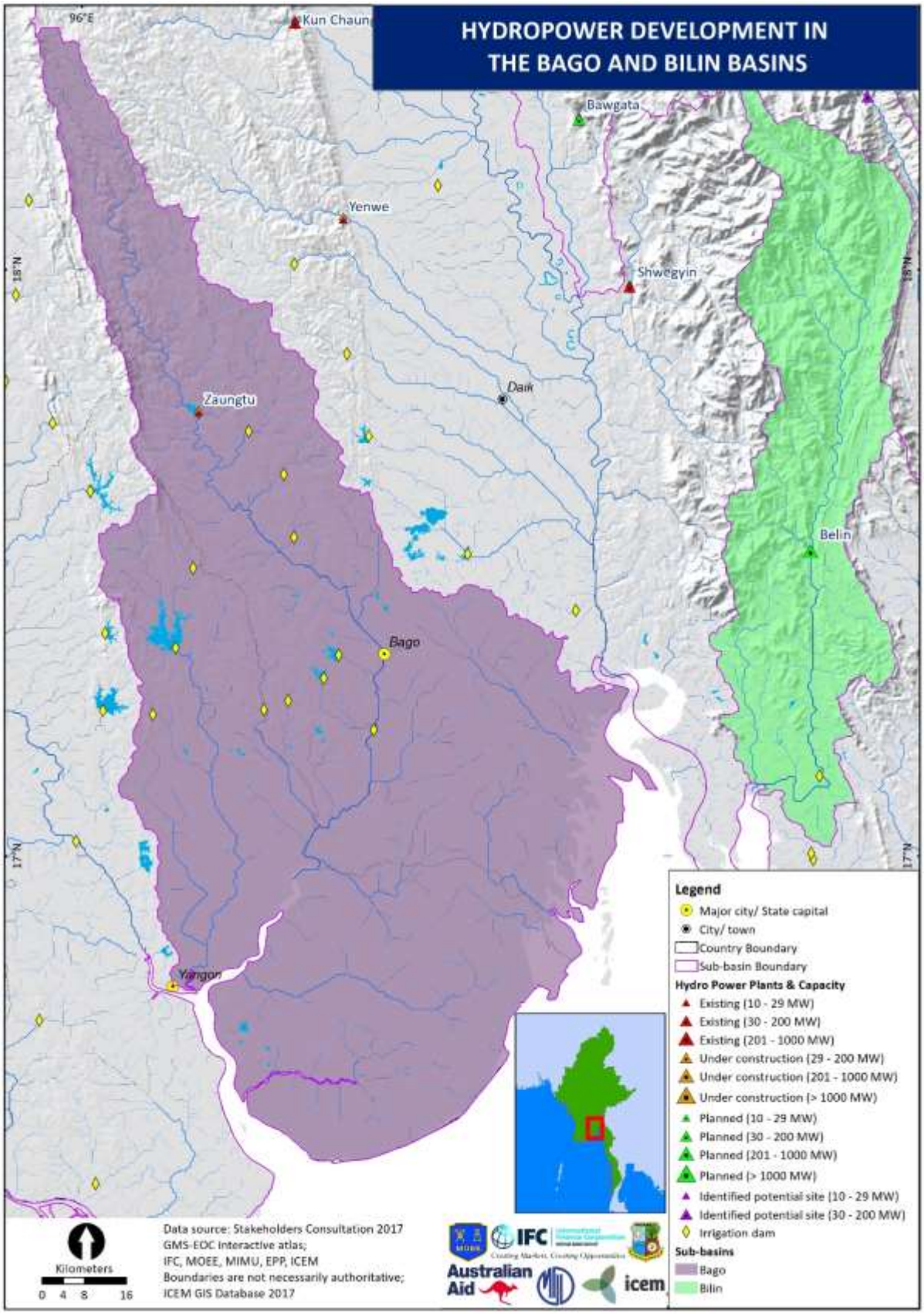


Table 5.68: Bago River - Existing Hydropower Plant

Power Plant	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Storage (hm^3)	Reservoir Area (km^2)	Reservoir Length (km)	Distance dam to power-house (km)	Developer	Year
Zaungtu	20	76	45	407	15	19	-	MoEE	1994

Zaungtu: The 20 MW Zaungtu hydropower plant completed in 1994 by MoEE. Its 45 m high embankment dam created a 19 km long reservoir with a surface area of 15 km^2 and storage of 407 hm^3. Figure 5.24 shows its location. Although the s/s outgoing voltage level at the power plant is 132 kV MoEE data says that the power plant is connected to Kamarnat s/s by a 73 km long 66 kV transmission line.

5.12 Bilin Basin

The Bilin River rises in Papun Township, Kayin State and flows about 210 km southwards flowing into the Gulf of Martaban. The basin catchment area is 3,057 km^2 (see Figure 5.24). Only one hydropower project is planned for this basin.

Table 5.69: Bilin Basin - Planned Projects - Key Data

Project	Installed Capacity (MW)	Generation (GWh)	Dam Height (m)	Total Storage (hm^3)	Reservoir Area (km^2)	Retention Period (days)	Type (+)	Export
Belin	280	NP	131	9,711	310	578	S	0%

(+) S: storage reservoir; (NP) No data

Table 5.70: Bilin Basin - Planned Projects - Development Process

Project	Date submitted EIA	Stage	Date Signed	Foreign Developer	Local Developer	Developer	Year
Belin	n.a.	Local MoU	20/03/16	-	HCDG	HCDG	2021

Belin: The 280 MW Belin HPP in Belin Township in Mon State will have a 131 m high dam. The dam will create a large reservoir of 310 km^2 storing 9,711 hm^3. The mean annual inflow to the reservoir is 190 m^3/s.[111] HCDG of Myanmar signed a local MoU with MoEE on 20 March 2016 for the development of the project under a BOT arrangement. The project is presently at the feasibility stage. The power plant would be connected to Thaton s/s by a 61 km long 230 kV transmission line.

5.13 Impact assessment

The status of existing HPPs at the basin level provides the foundation for analysis in this baseline report for each of the key themes. During the impact assessment phase, the SEA team will define the business as usual (BAU) case to 2035 based on analysis of the planned HPPs in each of the major basins. BAU is defined as projects 'most likely' to proceed in the next 20 years based on the development process and key technical data with in the HPP database. The team will overlay the

[111] The unit flow of 84 l/s/km^2 based on rainfall of 3,700 mm and catchment area at the dam site of 2,250 km^2.

location of existing and pipeline hydropower projects on critical E&S values to categorise projects in terms of potential impact on significant biodiversity, geomorphology and sediment transport, fisheries and aquatic ecology, livelihoods, and conflict and ethnic minorities. The impact on other economic sectors will also be assessed.

ANNEX A METHODOLOGY FOR COMPILING HPP DATABASE

Data Collection

The SEA Consultant prepared a Microsoft EXCEL file with five sheets to help collect data on each of the existing hydropower plants and proposed projects in the list agreed to with MoEE.

The first sheet: "*Resources*" aimed at collecting data on basin characteristics such as name of river, reservoir characteristics, hydro-meteorological data and sediment data. Except for the sediment data, it was possible to obtain relevant information for most projects.

The second sheet: "*TechData*" aimed to collect technical information about each power plant such as location of dam and powerhouse, physical characteristics of the most important hydropower plant components (dam, headrace, penstock, power station including generation equipment, tailraces, switchyard, transmission line and access road). For existing power plants, it was possible to get much of the information. For many of the proposed projects, however, obtaining information was more difficult, the reason being that many of the projects is still at pre-feasibility or feasibility stage, and has not yet been approved by MoEE. The information about these projects may still change as the projects develop further.

The third sheet: "*Development*" collected information about type of development agreement, name and country of developer, export arrangements, and dates of the various stages in the development process up to commissioning.

The fourth sheet: "*Econ&Financial*" aimed at obtaining cost data for each of the main contract types: civil works, electro-mechanical, switchyard/s/s, transmission, access roads, environmental mitigation and resettlement compensation. Very little information was available here.

The fifth sheet: "*Socio-economic*" aimed at obtaining information on social impacts such land acquisition, resettlement, etc. There was little specific socio-economic information available for any of the projects.

Quality Control of Provided data

On obtaining the names and coordinates of each project, we first plotted them on Google Earth (GE) since location is one of the most important data on the GIS mapping. For existing power plants, this allowed us to check that the coordinates were correct since the dams and power stations are visible in the satellite images. It was also possible to check location of power station (the coordinates for these were not provided by MoEE), type of headrace (tunnel or canal) and location of irrigation weirs downstream of the dam in the case of multipurpose projects. As reservoir inundation data was not available for some of the existing reservoirs, we also measured the reservoir area using the GE polygon measurement tool. As a double check, we used a tool in the Global Surface Water (GSW) web site,[112] which shows information about change in the Earth's water bodies (used for flooding, reservoir expansion and contraction, etc.) over the last 32 years. For those projects that could not be seen for a given set of coordinates, we made a visual search along the named rivers identifying dams, waterways and power stations. We used also this method to find existing projects in PRC and India for rivers that entered Myanmar from those two countries (Namtabak, Dapein, Shweli, and Manipur) and the coordinates of more than 100 existing irrigation dams in Myanmar.

For proposed projects, we found that for a good number of the projects, the given coordinates did not make sense. The coordinates of some of the dams located the projects on top of a mountain or in rice fields far from the river they were supposed to be in, or in a different river all-together. For some projects the ground elevation at a given dam site did not correspond with the given full supply level (FSL) and the dam height (e.g., the cascade projects on N'Mai Hka in the Ayeyarwady Headwaters). We attempted to correct this by using the available information (dam height, FSL, head on turbine,

[112] https://global-surface-water.appspot.com/

visual inspection of suitability of site, comparison with drawings or photos obtained in the internet) to adjust the coordinates. The result is sufficiently accurate for the purpose of the SEA, but obviously not for detail design. When significant corrections are made, these are noted in the text in footnotes linked to the project in question.

MoEE did not provide the coordinates of the proposed power station locations. When the head on the turbine exceeded the height of the FSL above the ground level at the dam site, we presumed the power station could be at some distance downstream from the dam. If the tailwater level (TWL) had been provided, we looked for the place on the river that equalled that elevation. If not, we computed the theoretical TWL by adding 10% to the head and subtracted from FSL. After finding the corresponding location in GE we checked that it was a reasonable place to physically locate the power station.

Since reservoir lengths along the main river channel is often not provided in feasibility studies, once the coordinates of the dam site had been decided, we measured in GE the length of river upstream of the dam until the elevation of the river equalled FSL.

In addition to performing a quality check on dam site and power station location, we also performed quality checks on various other sets of data: hydrology (checked that runoff coefficient was less than 1; sum of monthly flows corresponded to declared mean annual flow), reasonableness of reservoir volume and area (visual checks and rough measurements in GE), reasonableness of turbine discharge and head versus installed capacity, gross head exceeded design head, etc. When missing hydro-meteorological data, we obtained this from other GIS based databases.

ANNEX B HYDROPOWER DATABASE

The tables below show a summary of the hydropower database with the main technical parameters relevant for the SEA study.

ANNEX B.1 HYDROPOWER DATABASE - AYEYARWADY RIVER BASIN

ID	Hydropower Plant	Status	Status 2	LAT N	LON E	State/Region	District	Township	Village	Basin	Sub-Basin	River/ Watershed		HP or Multipurpos	D/S Distance to irrigation extraction if not from dam (km)
9	Belin	LocMoU	P	17.519723	97.243546	Mon	Thaton	Bilin		Bilin	Bilin	Bilin River		HP	
64	Myitsone	JVA	P	25.715000	97.535000	Kachin	Myitkyina	Myitkyina		Ayeyarwady	Ayeyarwady	Ayeyarwady		HP	
15	Chipwi Nge	Built	E	25.806073	98.184039	Kachin	Myitkyina	Chipwi	Chipwi	Ayeyarwady	Ayeyarwady Headwaters	Chipwi Hka		HP	
53	Laza	JVA	P	26.491779	97.776950	Kachin	Puta-O	Sumprabum	Sumprabum	Ayeyarwady	Ayeyarwady Headwaters	Mali Hka		HP	
14	Chipwi	JVA	P	25.890500	98.125720	Kachin	Myitkyina	Chipwi	Chipwi	Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka		HP	
44	Khaunglanphu	MOA	P	26.849507	98.376808	Kachin	Puta-O	Kanglanphu		Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka		HP	
30	Pisa	MOA	P	26.598389	98.343090	Kachin	Putau	Kanglanphu		Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka		HP	
103	Renan	MOA	P	27.525941	98.090192	Kachin	Puta-O	Khawbude		Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka		HP	
125	Wutsok	MOA	P	26.403585	98.292511	Kachin	Myitkyina	Myitkyina	Na Zun Baw	Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka		HP	
21	Dum Ban	MOU	P	25.511556	97.907021	Kachin	Myitkyina	Wyunmaw	Sadon	Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka Tributary		HP	
71	Nam Li	MOU	P	25.369858	97.811427	Kachin	Myitkyina	Wyunmaw	Sadon(Twn)	Ayeyarwady	Ayeyarwady Headwaters	N'Mai Hka Tributary		HP	
23	Gaw Lan	JVA	P	26.051936	98.580461	Kachin	Myitkyina	Chipwi		Ayeyarwady	Ayeyarwady Headwaters	Naw Chang Hka		HP	
28	Hkankawn	MOA	P	26.023865	98.429523	Kachin	Myitkyina	Tsawlaw	Tsawlaw	Ayeyarwady	Ayeyarwady Headwaters	Naw Chang Hka		HP	
51	Lawngdin	MOA	P	26.043012	98.277743	Kachin	Myitkyina	Tsawlaw	Tsawlaw	Ayeyarwady	Ayeyarwady Headwaters	Naw Chang Hka		HP	
121	Tongxinqiao	JVA	P	25.963646	98.360249	Kachin	Myitkyina	Myitkyina	Tsawlaw	Ayeyarwady	Ayeyarwady Headwaters	Naw Chang Hka		HP	
31	Tamanthi	Suspended	P	25.322227	95.296955	Sagaing	Hkamti	Htamanthi	Homemalin	Chindwin	Chindwin	Chindwin		HP	
58	Manipur	MOU	P	22.804356	93.943248	Chin	Falam	Kalay		Chindwin	Manipura	Manipura		HP	
65	Myittha	Built	E	21.992222	94.036944	Magway	GaNaw	GaNaw		Chindwin	Myittha	Myittha		Multi	
155	U Yu Chaung	Identified	I	24.865948	95.294431	Sagaing	Hkamti			Chindwin	Uyu	Uyu			
149	Ta Rung Hka	Identified	I	26.718029	96.468290	Kachin	Myitkyina		TaKyet	Chindwin	Chindwin Headwater 1	Ta Rung Hka			
150	Ta Nai Hka	Identified	I	26.294175	96.950080	Kachin	Myitkyina		Aung Lut	Chindwin	Chindwin Headwater 2	Ta Nai Hka			
148	Tawog Hka	Identified	I	26.309687	96.529870	Kachin	Myitkyina		Nam Gawn	Chindwin	Chindwin Headwater 2	Nam Lanog Hka			
17	Dapein 1	Built	E	24.421451	97.525448	Kachin	Bhamo	Bhamo		Ayeyarwady	Dapein	Dapein		HP	
18	Dapein 2	MOU	P	24.368270	97.421400	Kachin	Bhamo	Moemauk		Ayeyarwady	Dapein	Dapein		HP	
105	Sedawgyi	Built	E	22.348646	96.326937	Mandalay	Pyinoolwin	Mandalay		Ayeyarwady	Ma Gyi Chaung	Ma Gyi Chaung		Multi	3.8
106	Sedawgyi (upper)	GOM Plan	P	22.747640	96.206260	Shan	Kyaukme	Mandalay		Ayeyarwady	Ma Gyi Chaung	Ma Gyi Chaung		Multi	
136	Mali	Built	E	24.984580	97.613500	Kachin	Myitkyina	Waingmaw	Gau Dau Yang	Ayeyarwady	Mali Creek	Mali Creek		HP	
160	Mindon	Identified	I	19.370890	94.712866	Magway	Thayet			Ayeyarwady	Minodon				
11	Buywa	Construction	C	20.658056	94.150833	Magway	Minbu	Setotaya		Ayeyarwady	Mone Chaung	Mon Chaung		Multi	
10	Buywa (upper)	GOM Plan	P	20.766090	94.081800	Magway	Minbu	Setotaya		Ayeyarwady	Mone Chaung	Mon Chaung		Multi	
49	Kyee Ohn Kyee Wa	Built	E	20.331000	94.416000	Magway	Minbu	Sidoktaya		Ayeyarwady	Mone Chaung	Mon Chaung		Multi	9.4
62	Mone Chaung	Built	E	20.479942	94.255325	Magway	Minbu	Setoktaya	Aukpone	Ayeyarwady	Mone Chaung	Mon Chaung		Multi	
118	Thapanzeik	Built	E	23.305918	95.358330	Sagaing	Shwebo	Kyun Hla	Ngapyawtine	Ayeyarwady	Mu	Mu River		Multi	11.5
20	Deedoke	MOU	P	21.687230	96.404455	Mandalay	Pyinoolwin	Kyaukse	Hngel Kyi Thaik	Ayeyarwady	Myitnge	Lower Myitnge		HP	
129	Yeywa	Built	E	21.675196	96.474077	Mandalay	Pyinoolwin	Kyaukse	Ye Yaman	Ayeyarwady	Myitnge	Lower Myitnge		HP	
130	Yeywa (middle)	MOU	P	21.960240	96.873130	Shan	Kyaukme	Nawng Khio	Yedwingyi	Ayeyarwady	Myitnge	Lower Myitnge		HP	
131	Yeywa (upper)	Construction	C	22.254093	97.046741	Shan	Pyinoolwin	Kyautme		Ayeyarwady	Myitnge	Lower Myitnge		HP	
68	Nam Hsim	MOU	P	22.560266	97.124079	Shan	Hsipaw			Ayeyarwady	Myitnge	Myitnge Upper		HP	
70	Nam Lang	MOU	P	22.155565	97.248615	Shan	Hsipaw			Ayeyarwady	Myitnge	Myitnge Upper		HP	
83	Nam Tu	LocMoU	P	22.720943	97.319365	Shan	Kyaukme	Hsipaw		Ayeyarwady	Myitnge	Myitnge Upper		HP	
45	Kinda	Built	E	21.160437	96.321037	Shan	Taunggyi	Kyaukse	Kanzwe	Ayeyarwady	Myitnge	Panlaung Chaung		Multi	16.8
66	Myogyi	Built	E	21.463490	96.391440	Shan	Taunggyi	Ywa Ngan		Ayeyarwady	Myitnge	Zawgyi River		Multi	8.9
134	Zawgyi I	Built	E	21.383300	96.901470	Shan	Taunggyi	Yaksauk		Ayeyarwady	Myitnge	Zawgyi River		HP	
135	Zawgyi II	Built	E	21.564800	96.872600	Shan	Taunggyi	Yaksauk		Ayeyarwady	Myitnge	Zawgyi River		Multi	
82	Nam Tabak I	MOA	P	25.090722	97.713906	Kachin	Myitkyina	Waingmaw	Waingmaw	Ayeyarwady	Namtamhpak	Namtamhpak		HP	
136	Nam Tabak II	MOA	P	25.119755	97.650627	Kachin	Myitkyina	Waingmaw	Waingmaw	Ayeyarwady	Namtamhpak	Namtamhpak		HP	
73	Nam Paw	Covenant	P	23.944341	97.911001	Shan	Muse	Muse	Selan	Ayeyarwady	Shweli	Nam Paw Creek		HP	
108	Shweli 1	Built	E	23.698000	97.506000	Shan	Muse	Manthet Village	Nam Hkan	Ayeyarwady	Shweli	Shweli		HP	
109	Shweli 2	MOA	P	23.653100	97.312350	Shan	Muse	Namkham		Ayeyarwady	Shweli	Shweli		HP	
110	Shweli 3	Construction	C	23.315000	96.769000	Shan	Kyaukme	Namkham		Ayeyarwady	Shweli	Shweli		HP	

ID	Hydropower Plant		Catchment Area (km2)	Catchment Annual rainfall (mm)	Mean annual inflow (MAF) into reservoir (m3/s)	Unit flow l/s/km2	Qmin/ MAF		Dam Type	Dam Height (m)	Full Supply Level (FSL) (m)	Low Water Level (LWL) (m)	Drawdown (m)		Reservoir Area (km2)	Total Length of reservoir (km)
9	Belin		2,250	3,700	190.0	84.4	5%			131					310.0	
64	Myitsone		48,782	3,234	5,040.0	103.3	12%		CFRD	140	245	230	15		397.0	140.0
15	Chipwi Nge		552		40.1	72.6	12%		CG	48	740	735	5		0.1	0.7
53	Laza		15,291	3,000	1,890.0	123.6	22%		CFRD	196	370	340	30		245.5	115.0
14	Chipwi		21,734		2,210.0	101.7	22%		CFRD	203	400	385	15		27.7	62.0
44	Khaunglanphu		14,655		1,500.0	102.4	11%		CFRD	223	875	825	50		32.9	85.0
30	Pisa		16,689	3,000	1,730.0	103.7	4%		CFRD	153	665	650	15		7.9	31.0
103	Renan		11,123		1,070.0	96.2	10%		CFRD	159	1,010	980	30		9.2	56.0
125	Wutsok		18,225		1,910.0	104.8	11%		CFRD	165	525	510	15		6.3	29.0
21	Dum Ban		660	2,822	38.4	58.2	29%		CG	81	405	370	35			5.0
71	Nam Li		418	2,913	26.7	63.9	29%		CG	44	590	577	13			1.0
23	Gaw Lan		740	3,500	56.1	75.8	8%		CG	47	1,510	1,495	15		6.7	3.0
28	Hkankawn		1,326	3,625	96.5	72.8	32%			42					2.0	2.8
51	Lawngdin		2,080	3,124	154.0	74.0	33%			79					12.4	10.7
121	Tongxinqiao		1,743	3,268	135.1	77.5	32%		CG	63	1,075	1,060	15		8.8	4.0
31	Tamanthi		109	2,964	3,573.0	108.8	16%			74					509.0	
58	Manipur		11,549	1,500	193.0	16.7	34%			168						45.0
65	Myittha		1,813		43.9	24.2	4%		Earth	63					12.2	
155	U Yu Chaung		9,495		629.0	66.2										
149	Ta Rung Hka		4,837		463.0	95.7										
150	Ta Nai Hka		2,095		168.0	80.2										
148	Tawog Hka		76		6.6	86.8										
17	Dapein 1		6,002	1,330	319.0	53.1	19%		Concrete	46	250				0.4	3.6
18	Dapein 2		6,220	1,330	331.0	53.2	19%		CG	59	179	174	5			8.0
105	Sedawgyi		3,424		131.6	38.4	15%		Rockfill	41	129				40.5	16.1
106	Sedawgyi (upper)		2,640	889	101.0	38.3	16%			73					24.0	
136	Mali		290		14.2	49.0	20%									
160	Mindon		676		24.0	35.5										
11	Buywa		3,108							46					38.1	
10	Buywa (upper)		2,305		79.0	34.3	9%			138					76.2	
49	Kyee Ohn Kyee Wa		5,100		126.9	24.9	10%		Earth	50	120				32.8	29.8
62	Mone Chaung		3,695		97.3	26.3	10%		Rockfill	61	167				41.5	19.4
118	Thapanzeik		9,338		209.0	22.4	9%		Earth	33	159				397.1	42.8
20	Deedoke		28,695	1,300	491.4	17.1	21%		RCC Gravity Dam	27	80	74	6			19.0
129	Yeywa		28,206	838	483.0	17.1	33%		RCC	132	185	150	35		59.0	75.0
130	Yeywa (middle)		25,490	1,300	412.0	16.2	32%		RCC/Arch dam	160	320	300	20		11.0	70.0
131	Yeywa (upper)		21,700	1,270	371.0	17.1	32%		RCC	97	395	385	10		26.9	54.0
68	Nam Hsim		1,368		35.4	25.9	19%									
70	Nam Lang		6,664	1,150	143.0	21.5	17%									
83	Nam Tu		6,832		129.6	19.0	21%		CG	114	492	479	13			4.0
45	Kinda		2,240		34.7	15.5	20%		Rockfill	72	193				28.6	14.5
66	Myogyi		3,873		70.9	18.3	16%			79	193				9.7	10.7
134	Zawgyi I		1,406		30.0	21.3	16%			-	833				-	-
135	Zawgyi II		1,907		42.8	22.4	16%		Earth	44	653				38.5	8.2
82	Nam Tabak I		1,121	2,500	79.4	70.8	7%		CG	56	316	302	14		2.2	0.6
136	Nam Tabak II		1,289	2,500	80.0	62.1	20%		CG	27	476	472	4			2.6
73	Nam Paw		1,025	1,418	32.6	31.8	18%			54	805	795	10			1.3
108	Shweli 1		12,597	1,418	400.0	31.8	29%		CG	47	745				1.1	10.5
109	Shweli 2		13,265	1,418	405.2	30.5	25%		CFRD	92	395	375	20		27.9	20.0
110	Shweli 3		14,810	1,418	452.0	30.5	25%		RCC	122	235	195	40		118.0	65.0

ID	Hydropower Plant	Reservoir Dead Storage (hm3)	Reservoir Live Storage (hm3)	Reservoir Total Storage (hm3)	Reservoir Retention period (days)	RoR or Storage		Distance along river between dam and powerhouse (km	Powerhouse Type	Total Powerplant Design Discharge (m3/s)	Turbine discharge/ Min Flow	Turbine Design Head (m)	Installed Capacity (MW)	Annual Generation (GWh)	Firm Power (MW)	Plant Factor
9	Belin	220	9,491	9,711	578	S		-					280			-
64	Myitsone	8,687	4,503	13,190	10	S		-	Above ground	7,158	11.8	96	6,000	31,290	1,244	0.60
15	Chipwi Nge	1	0	1	0	RoR		16.7	Above ground	26	5.6	433	99	599	26	0.69
53	Laza	6,080	5,700	11,780	35	S		-		1,844	4.4	118	1,900	14,720		0.88
14	Chipwi	1,530	380	1,910	2	RoR		-	Underground	2,762	5.7	141	3,400	18,200		0.61
44	Khaunglanphu	1,574	1,526	3,100	12	S		-	Underground	1,611	9.5	192	2,700	14,730		0.62
30	Pisa	306	229	535	2	RoR		-	Underground	1,804	15.4	127	2,000	12,870		0.73
103	Renan	605	578	1,183	6	S		-	Ground	1,082	16.1	127	1,200	7,330		0.70
125	Wutsok	455	150	605	1	RoR		-		1,718	8.4	120	1,800	13,410		0.85
21	Dum Ban	4	30	34	9	S		3.4	Underground	83	7.5	178	130	371	16	0.33
71	Nam Li	0	1	2	1	RoR		15.0		33	4.3	322	165	473	19	0.33
23	Gaw Lan	0	1	1	0	RoR		11.0	Above ground	76	17.4	175	120	594	25	0.56
28	Hkankawn	2	3	5	0	RoR		-					140	769		0.63
51	Lawngdin	27	40	67	3	RoR		-					600	2,401		0.46
121	Tongxinqiao	2	4	5	0	RoR		13.0	Bankside	146	3.3	260	340	1,695	61	0.57
31	Tamanthi	6,312	14,610	20,922	47	S		-					1,200	6,685		0.64
58	Manipur	769	874	1,643	52	S		-					380	1,903		0.57
65	Myittha	153	172	325	45	S		-		38	24.0	53	40	170		0.49
155	U Yu Chaung												12.0			
149	Ta Rung Hka												150.0			
150	Ta Nai Hka												15.0			
148	Tawog Hka												50.0			
17	Dapein 1	8	15	22	1	RoR		4.3	Above ground				240	1,065	30	0.51
18	Dapein 2	19	36	55	1	RoR		-	Above ground	380	5.9	42	140	642	18	0.52
105	Sedawgyi	104	344	448	30	S		-	Above ground				25	134	20	0.61
106	Sedawgyi (upper)	112	481	593	55	S		-					64			-
136	Mali					ROR		5.7					11	54		0.58
160	Mindon												18.0			
11	Buywa	70	139	209	-	-		-					42			-
10	Buywa (upper)	602	119	721	17	S		-					150	534		0.41
49	Kyee Ohn Kyee Wa	-	571	571	52	S		-	Above ground				74	370	42	0.57
62	Mone Chaung	190	642	832	76	S		-	Above ground				75	330	38	0.50
118	Thapanzeik	481	3,072	3,552	170	S		-	Above ground				30	117	13	0.45
20	Deedoke			13		ROR		-	In dam	700	6.6	10	66	338		0.58
129	Yeywa	1,000	1,630	2,630	39	S		-	Above ground	840	5.3	91	790	3,550	175	0.51
130	Yeywa (middle)	258	196	454	6	S		-	Underground	592	4.5	135	700	3,253		0.53
131	Yeywa (upper)	145	196	341	6	S		-	Above ground	127	4.2	67	280	1,409		0.57
68	Nam Hsim							-					30			
70	Nam Lang							-					210			
83	Nam Tu									113	4.1	85	100	635	47	0.72
45	Kinda	207	871	1,078	290	S		-	Above ground				56	165		0.34
66	Myogyi	170	274	443	45	S		-	Above ground				30	136	16	0.52
134	Zawgyi I	-	-	-		RoR		1.7	Above ground				18	35	4	0.22
135	Zawgyi II	123	516	639	139	S		-	Above ground				12	30	3	0.29
82	Nam Tabak I	14	0	15	0	RoR		6.0	Above ground	113	19.3	144	141	684	28	0.54
136	Nam Tabak II					ROR		10.0	Above ground	108	7.1	145	144	635	25	0.50
73	Nam Paw	21	31	52	11	S		-	At dam toe	59	10.3	39	20	83	3	0.48
108	Shweli 1							9.5	Above ground	230	2.0	299	600	4,022	175	0.77
109	Shweli 2	30	42	72	1	RoR		-	Bankside	526	5.2	110	520	2,814	138	0.62
110	Shweli 3	1,854	3,610	5,464	92	S		-	Above ground	1,200	10.5	88	1,050	3,400	532	0.37

ID	Hydropower Plant	Transmission Line Voltage level (kV)	TL Length (km)	TL Connected to S/S	Developer	Country	Investment by	Installed Capacity (MW)	Myanmar Selfuse (MW)	% use MYA	Export (MW)	Export to	Estimated No. Construction Workers (planned projects)	Camp followers X2
9	Belin	230	61	Thaton	HCDG	Myanmar	Local BOT	280	280	100%	-		1,100	2,200
64	Myitsone				CPIYN/AWC	PRC/MYA	Foreign JV/BOT	6,000	600	10%	5,400	PRC	14,200	28,400
15	Chipwi Nge	132	98	Waingmaw	SPIC	PRC	Foreign JV/BOT	99	20	20%	79			
53	Laza				CPIYN	PRC	Foreign JV/BOT	1,900	950	50%	950		6,800	13,600
14	Chipwi				CPI	PRC	Foreign JV/BOT	3,400	340	50%	1,700	PRC	10,700	21,400
44	Khaunglanphu				CPI	PRC	Foreign JV/BOT	2,700				PRC	9,100	18,200
30	Pisa				CPI	PRC	Foreign JV/BOT	2,000				<-PRC?	7,100	14,200
103	Renan				CPI	PRC	Foreign JV/BOT	1,200				PRC	4,600	9,200
125	Wutsok				CPI	PRC	Foreign JV/BOT	1,800				PRC	6,500	13,000
21	Dum Ban				YBEP/Chan Yinn Khuu	PRC/MYA	Foreign JV/BOT	130	130	100%	-		500	1,000
71	Nam Li				YBEP/Chan Yinn Khuu	PRC/MYA	Foreign JV/BOT	165	165	100%	-		700	1,400
23	Gaw Lan	230	15	Hawkawn	YEIG/IGOEC	PRC/MYA	Foreign JV/BOT	120	60	50%	60		500	1,000
28	Hkankawn	230	15	Tongxinqiao	YEIG/IGOEC	PRC/MYA	Foreign JV/BOT	140	70	50%	70	<-PRC?	600	1,200
51	Lawngdin	230	16	Tongxinqiao	YEIG/IGOEC	PRC/MYA	Foreign JV/BOT	600	300	50%	300	<-PRC?	2,400	4,800
121	Tongxinqiao	500	130	Winemaw	YEIG/IGOEC	PRC/MYA	Foreign JV/BOT	340	170	50%	170	<-PRC?	1,400	2,800
31	Tamanthi				NHPC	India	Foreign JV/BOT	1,200				India	4,600	9,200
58	Manipur	230	32	GaNaw-Kalay In/out	CHEC/Sein	PRC/MYA	Foreign JV/BOT	380	380	100%	-		1,500	3,000
65	Myittha	66	40	GaNaw	MOALI	Myanmar	Sole Investment	40	40	100%	-			
155	U Yu Chaung				NA	NA	NA						50	100
149	Ta Rung Hka				NA	NA	NA						600	1200
150	Ta Nai Hka				NA	NA	NA						100	200
148	Tawog Hka				NA	NA	NA						200	400
17	Dapein 1	132	37	Bamaw	China Datang	PRC	Foreign JV/BOT	240	19	8%	221	PRC		
18	Dapein 2	230	16	Dapein1	DUHD	PRC	Foreign JV/BOT	140	70	50%	70		600	1,200
105	Sedawgyi	132	212	Kyaukpahto	MoEE	Myanmar	Sole Investment	25	25	100%	-			
106	Sedawgyi (upper)	132	212+48	Kyaukpahto/Aungpinle	MOALI	Myanmar	Sole Investment	64	64	100%	-		300	600
136	Mali				Buga Co.	Myanmar	Local BOT	11	11	100%	-			
160	Mindon				NA	NA	NA						100	200
11	Buywa				MOALI	Myanmar	Sole Investment	42	42	100%	-			
10	Buywa (upper)				MOALI	Myanmar	Sole Investment	150	150	100%	-		600	1,200
49	Kyee Ohn Kyee Wa	132	70	Mann	MOALI	Myanmar	Sole Investment	74	74	100%	-			
62	Mone Chaung	132	160	Chauk	MoEE/MOALI	Myanmar	Sole Investment	75	75	100%	-			
118	Thapanzeik	132	53	Ngapyadaing	MoEE/MOALI	Myanmar	Sole Investment	30	30	100%	-			
20	Deedoke	230	21	Yeywa	Andritz Hydro	Austria	Foreign JV/BOT	66	66	100%	-		300	600
129	Yeywa	230	38 + 118	Belin, Meiktila	MoEE	Myanmar	Sole Investment	790	790	100%	-			
130	Yeywa (middle)	TBD	TBD	500kV Meilhtila S/S	SN Power	Norway	Foreign JV/BOT	700	700	100%	-		2,800	5,600
131	Yeywa (upper)	230	130	Shwesaryan	MoEE	Myanmar	Sole Investment	280	280	100%	-			
68	Nam Hsim				PCR/SE	PRC/MYA	Foreign JV/BOT	30	30	100%	-		100	200
70	Nam Lang				PCR/SE	PRC/MYA	Foreign JV/BOT	210	210	100%	-		900	1,800
83	Nam Tu				NCEH	Myanmar	Local BOT	100	100	100%	-		400	800
45	Kinda	132	73+47	Ingone,Thazi	MoEE	Myanmar	Sole Investment	56	56	100%	-			
66	Myogyi	33	16	Taungtawgwin	MOALI	Myanmar	Sole Investment	30	30	100%	-			
134	Zawgyi I	66	76	Aungthapye	MoEE	Myanmar	Sole Investment	18	18	100%	-			
135	Zawgyi II	66	23	Zawgyi1	MoEE/MOALI	Myanmar	Sole Investment	12	12	100%	-			
82	Nam Tabak I				China Guodian/Tun Thwin Mining)	PRC/MYA	Foreign JV/BOT	141				<-PRC?	600	1,200
136	Nam Tabak II				China Guodian/Tun Thwin Mining)	PRC/MYA	Foreign JV/BOT	144				<-PRC?	600	1,200
73	Nam Paw				Great Hor Kham	Myanmar	Local BOT	20	20	100%	-		100	200
108	Shweli 1	230	96	Mansan	YUPD	PRC	Foreign JV/BOT	600	400	67%	200	PRC		
109	Shweli 2	230	70	Shweli3	HIE/AWC	PRC/MYA	Foreign JV/BOT	520	260	50%	260	PRC	2,100	4,200
110	Shweli 3	500	420	Meikhtila	EDF SA	France	Foreign JV/BOT	1,050	1,050	100%	-			

ANNEX B.2 HYDROPOWER DATABASE - THANLWIN RIVER BASIN

ID	Hydropower Plant	Status	Status 2	LAT N	LON E	State/Region	District	Township	Village	Basin	Sub-Basin	River/ Watershed
152	Yunzalin	Identified	I	18.294960	97.340810	Kayin	Panan			Thanlwin	Yunzalin	
33	Hutgyi	MOA	P	17.528000	97.747000	Kayin	Hpapun	Kamamung		Thanlwin	Thanlwin Mainstem	Thanlwin Mainstem
48	KunLong	JVA	P	23.531667	98.611111	Shan	Kunlong	Kunlong	Huli	Thanlwin	Thanlwin Mainstem	Thanlwin Mainstem
57	Mong Ton	MOU	P	20.456389	98.650000	Shan	Monghsat	Mongtong		Thanlwin	Thanlwin Mainstem	Thanlwin Mainstem
92	Naopha	MOA	P	22.987464	98.499151	Shan	Lashio	Tangyan		Thanlwin	Thanlwin Mainstem	Thanlwin Mainstem
132	Ywathit	MOA	P	19.131059	97.521257	Kayah	Bawlake	Ywathit	Bawlakhe	Thanlwin	Thanlwin Mainstem	Thanlwin Mainstem
38	Keng Tawng	Built	E	20.598345	98.293050	Shan	Linkhe	Moenane		Thanlwin	Nam Teng	Nam Teng
39	Keng Tawng (upper)	Construction	C	20.745580	98.184077	Shan	Linkhe	Keng Tawng		Thanlwin	Nam Teng	Nam Teng
7	Baluchaung (upper)	Construction	C	20.484592	96.781918	Shan	Taunggyi	Pin Laung	Indein	Thanlwin	Nam Pawn	Baluchaung
2	Baluchaung 1	Built	E	19.648000	97.287000	Kayah	Loikaw	Loikaw		Thanlwin	Nam Pawn	Baluchaung
4	Baluchaung 2	Built	E	19.557000	97.358000	Kayah	Loikaw	Loikaw		Thanlwin	Nam Pawn	Baluchaung
6	Baluchaung 3	Built	E	19.546000	97.397000	Kayah	Loikaw	Loikaw		Thanlwin	Nam Pawn	Baluchaung
26	Hawkham (upper)	MOU	P	19.211667	97.399722	Kayah	Bawlakhe			Thanlwin	Nam Pawn	Nam Pawn
99	Hpak Nam	MOU	P	20.209251	97.456152	Shan	Hpi Hseng			Thanlwin	Nam Pawn	Nam Pawn
100	Hpi Hseng	MOU	P	20.118443	97.434970	Shan	Hpi Hseng			Thanlwin	Nam Pawn	Nam Pawn
55	Nam Pawn (lower)	MOU	P	19.555000	97.408611	Kayah	Loikaw			Thanlwin	Nam Pawn	Nam Pawn
77	Nam Pawn (upper)	MOU	P	20.062121	97.437368	Shan	Hpi Hseng			Thanlwin	Nam Pawn	Nam Pawn
59	Mantong	MOA	P	22.974690	98.557270	Shan	Hopang	Minemaw		Thanlwin	Nam Ma	Nam Ma
67	Nam Hka	MOU	P	21.733821	98.950044	Shan	Hopang	Mong Sat		Thanlwin	Nam Hka	Nam Hka
159	Myet Taw Chaung	Identified	I	15.682011	97.915769	Kayin	Kawareik			Thanlwin	Myet Taw Chaung	Myet Taw Chaung
153	Lam Pha	Identified	I	16.305021	98.348758	Kayin	Kawareik		Lam Pha	Thanlwin	Lam Pha	Lam Pha

ID	Hydropower Plant	HP or Multipurpose	D/S Distance to irrigation extraction if not from dam (km)		Catchment Area (km2)	Catchment Annual rainfall (mm)	Mean annual inflow (MAF) into reservoir (m3/s)	Unit flow l/s/km2	Qmin/ MAF		Dam Type	Dam Height (m)	Full Supply Level (FSL) (m)	Low Water Level (LWL) (m)	Drawdown (m)		Reservoir Area (km2)	Total Length of reservoir (km)
152	Yunzalin				1,365		40.0	29.3										
33	Hutgyi	HP			311,167	2,436	4,409.0	14.2	32%		RCC Gravity Dam	118	48	40	8		27.1	16.0
48	KunLong	HP			128,989		1,910.0	14.8	27%		CG	103	519	511	8		65.4	55.0
57	Mong Ton	HP			183,265		2,776.0	15.1	32%			241	395				870.0	380.0
92	Naopha	HP			141,127		2,250.0	15.9	27%		RCC Gravity Dam	90	445	440	5		23.8	110.0
132	Ywathit	HP			208,984		3,400.0	16.3	33%		RCC Gravity Dam	167	215	200	15		43.5	130.0
38	Keng Tawng	HP			8,450		164.8	19.5	22%		CG	27					0.1	0.9
39	Keng Tawng (upper)	HP			7,510		146.4	19.5	23%		Rockfill	56					23.3	
7	Baluchaung (upper)	HP			356	1,925	11.1	31.1	43%			35	1,140	1,125	15		9.7	
2	Baluchaung 1	HP			7,872		36.5	4.6	81%		CG	11	867	864	3		0.0	0.2
4	Baluchaung 2	HP			7,910		38.0	4.8	79%		Weir	-	787	784	3		-	-
6	Baluchaung 3	HP			8,042		40.2	5.0	75%		Intake	-	339				-	-
26	Hawkham (upper)	HP			16,884	1,100	334.0	19.8	18%			72	206					29.0
99	Hpak Nam	HP			3,151	1,100	62.0	19.7	21%			20	900					1.0
100	Hpi Hseng	HP			3,265	1,100	64.6	19.8	21%			10	665					1.0
55	Nam Pawn (lower)	HP			7,860	1,100	155.6	19.8	19%			88	292	285	7			36.0
77	Nam Pawn (upper)	HP			3,352	1,100	66.4	19.8	21%			10	570					0.2
59	Mantong	HP			3,936	1,630	78.3	19.9	78%		CFRD	109	492	477	15		10.5	86.0
67	Nam Hka	HP			7,827	1,378	165.0	21.1	68%			120	483	460	23		75.1	80.0
159	Myet Taw Chaung				31		2.7	87.1										
153	Lam Pha				81		3.7	45.7										

ID	Hydropower Plant	Reservoir Dead Storage (hm3)	Reservoir Live Storage (hm3)	Reservoir Total Storage (hm3)	Reservoir Retention period (days)	RoR or Storage		Distance along river between dam and powerhouse (km)	Powerhouse Type	Total Powerplant Design Discharge (m3/s)	Turbine discharge/ Min Flow	Turbine Design Head (m)	Installed Capacity (MW)	Annual Generation (GWh)	Firm Power (MW)	Plant Factor		Transmission Line Voltage level (kV)	TL Length (km)
152	Yunzalin												100.0						
33	Hutgyi	338	171	509	0	RoR		-	At dam toe	648	3.7	30	1,360	7,325		0.61		230	
48	KunLong	483	208	691	1	RoR		-	At dam toe	620	6.1	54	1,400	7,142		0.58		230	68
57	Mong Ton	2,401	37,399	39,800	156	S		-					7,000	34,700		0.57			
92	Naopha	580	277	857	1	RoR		-					1,200	6,182		0.59			
132	Ywathit	7,427	3,330	10,757	11	S		-	Power House At Dam Toe	5,325	4.8	98	4,000	25,519		0.73			
38	Keng Tawng	9	52	61	4	S		2.2	Above ground	51	4.2	130	54	378	43	0.80		132	119
39	Keng Tawng (upper)	19	110	128	9	S		-	Semi underground	154	4.6	38	51	231		0.52		132	73
7	Baluchaung (upper)							3.0	Above ground	16	3.3	148	30	90	3	0.34		66	32
2	Baluchaung 1	-	2	2	1	RoR		10.3	Above ground	46	1.6	70	28	200	26	0.82		132	5
4	Baluchaung 2	-	-	-	-	RoR		7.1	Above ground	48	1.6	422	168	1,190	155	0.81		230	153.79+193.2
6	Baluchaung 3	-	-	-	-	RoR		5.1	Above ground	51	1.7	114	52	334		0.73		132	5
26	Hawkham (upper)			333				-		360	5.9		180	755		0.48			
99	Hpak Nam			20				10.3	Underground	65	4.9		105	557		0.61			
100	Hpi Hseng			4				6.0		65	4.7		45	265		0.67			
55	Nam Pawn (lower)			526				-	At dam toe	260	8.7		105	618		0.67			
77	Nam Pawn (upper)			7				17.8		65	4.6		150	782		0.60			
59	Mantong	717	498	1,215	146	S		-	River-bank	282	9.1	86	225	936	63	0.47		500	105
67	Nam Hka	184	266	450	39	S		-					210	937		0.51			
159	Myet Taw Chaung												10.0						
153	Lam Pha												19.5						

ID	Hydropower Plant	TL Connected to S/S	Developer	Country	Investment by	Installed Capacity (MW)	Myanmar Selfuse (MW)	% use MYA	Export (MW)	Export to	Estimated No. Construction Workers (planned projects)	Camp followers X2
152	Yunzalin		NA	NA	NA						400	800
33	Hutgyi	230-kV TL Thaton SS and 33 kV TL Myainnggyingu SS MYA	Sinohydro+EGATi+IGOEC	PRC/THA/MYA	Foreign JV/BOT	1,360	136	10%	1,224	Thailand	5,100	10,200
48	KunLong	Theinni	Hanergy YN, MPC	PRC/MYA	Foreign JV/BOT	1,400	700	50%	700	PRC	5,200	10,400
57	Mong Ton		Three Gorges+EGAT	PRC/Thailand	Foreign JV/BOT	7,000	700	10%	6,300	Thailand	14,500	29,000
92	Naopha		HydroChina/IGOEC	PRC/MYA	Foreign JV/BOT	1,200	600	50%	600	PRC	4,600	9,200
132	Ywathit		CDOI/STH	PRC/MYA	Foreign JV/BOT	4,000	400	10%	3,600	Thailand	11,900	23,800
38	Keng Tawng	Namsan	MoEE	Myanmar	Sole Investment	54	54	100%	-			
39	Keng Tawng (upper)	Namsan	MoEE	Myanmar	Sole Investment	51	51	100%	-			
7	Baluchaung (upper)	Kalaw	NeoEnergy Oasis	Myanmar	Local BOT	30	30	100%	-			
2	Baluchaung 1	Baluchaung 2	MoEE	Myanmar	Sole Investment	28	28	100%	-			
4	Baluchaung 2	Taungoo and Shwemyo	MoEE	Myanmar	Sole Investment	168	168	100%	-			
6	Baluchaung 3	Baluchaung 3	Future Energy	Myanmar	Local BOT	52	52	100%	-			
26	Hawkham (upper)		TEI/HCTC	SIN/MYA	Foreign JV/BOT	180		0%			700	1,400
99	Hpak Nam		TEI/HCTC	SIN/MYA	Foreign JV/BOT	105	105	100%	-		400	800
100	Hpi Hseng		TEI/HCTC	SIN/MYA	Foreign JV/BOT	45	45	100%	-		200	400
55	Nam Pawn (lower)		TEI/HCTC	SIN/MYA	Foreign JV/BOT	105	105	100%	-		400	800
77	Nam Pawn (upper)		TEI/HCTC	SIN/MYA	Foreign JV/BOT	150	150	100%	-		600	1,200
59	Mantong	Theinni	HydroChina/IGOEC	PRC/MYA	Foreign JV/BOT	225	113	50%	113	PRC	900	1,800
67	Nam Hka		YNIC	PRC	Foreign JV/BOT	210	105	50%	105		900	1,800
159	Myet Taw Chaung		NA	NA	NA						40	80
153	Lam Pha		NA	NA	NA						100	200

ANNEX B.3 HYDROPOWER DATABASE - OTHER RIVER BASINS

ID	Hydropower Plant	Status	Status 2	LAT N	LON E	State/Region	District	Township	Village	Basin	Sub-Basin	River/ Watershed
165	Sar Ra Wa Chaung	Identified	I	12.829406	98.981670	Tanintharyi				Tanintharyi	Tanintharyi	
113	Taninthayi	Suspended	P	12.777000	98.940000	Tanintharyi	Tenasserim	Tanintharyi		Tanintharyi	Tanintharyi	Taninthayi
157	Tha Gyet Chaung	Identified	I	12.132896	99.227161	Tanintharyi				Tanintharyi	Tanintharyi	Tha Gyet
156	Thein Kun Chaung	Identified	I	11.769949	99.331205	Tanintharyi	Myeik			Tanintharyi	Tanintharyi	Thein Kun
158	Glohong Kra	Identified	I	10.775209	98.858324	Tanintharyi				Tanintharyi	Glohong Kra	Glohong Kra
86	Nancho	Built	E	19.741200	96.450483	Naypyitaw	Det Khi Na	Pyinmana		Sittaung	Paung Laung	Sin The Chaung
96	Paung Laung (lower)	Built	E	19.785000	96.335000	Naypyitaw	Det Khi Na	Pyinmana	Zayyarthiri	Sittaung	Paung Laung	Paung Laung Chaung
97	Paung Laung (middle	MOU	P	19.860000	96.508000	Mandalay	Nay Pyi Taw	Pyinmana		Sittaung	Paung Laung	Paung Laung Chaung
98	Paung Laung (upper)	Built	E	19.756000	96.598000	Mandalay	Nay Pyi Taw	Pyinmana		Sittaung	Paung Laung	Paung Laung Chaung
101	Phyu Chaung	Built	E	18.506214	96.351028	Bago	Taungoo	Phyu		Sittaung	Other Sittaung	Pyu Chaung
107	Shwegyin	Built	E	17.970227	96.935001	Bago	Bago	Shwegyin		Sittaung	Other Sittaung	Shwegyin River
151	Thauk Ye Khat 1	Identified	I	18.938587	96.719624	Kayin				Sittaung	Thauk Ye Khat	Thauk Ye Khat
120	Thauk Ye Khat 2	Built	E	18.914102	96.619907	Kayin	Hpa-An	Tangoo		Sittaung	Thauk Ye Khat	Thauk Ye Khat
127	Yenwe	Built	E	18.085211	96.446152	Bago	Bago	Kyauktaga	Myoechaung	Sittaung	Other Sittaung	Ye Nwe Chaung
8	Bawgata	LocMoU	P	18.255561	96.848496	Bago	Taungoo	Kyauk Gyi		Sittaung	Bawgata	Bawgata
161	Than Dwe	Identified	I	18.386144	94.493902	Rakhine	Thandwe	Thandwe		Rakhine	Than Dwe	Than Dwe
116	Thahtay	Construction	C	18.640000	94.381000	Rakhine	Thandwe	Thandwe		Rakhine	Thahtay	Thahtay
164	Saing Din	Identified	I	20.893779	92.652188	Rakhine		BuuTheeTaung		Rakhine	Saing Din Creeek	
52	Lemro 1	MOU	P	20.857443	93.350503	Chin	Mindat			Rakhine	Lemro	Le Mro
54	Lemro 2	MOU	P	20.740347	93.268689	Rakhine	Mrauk Oo	Mrauk Oo		Rakhine	Lemro	Le Mro
162	Kyein Ta Li	Identified	I	17.950012	94.576508	Rakhine				Rakhine	Kyein Ta Li	Kyein Ta Li
154	Mi Chaung	Identified	I	21.334187	93.073495	Chin	Mindat			Rakhine	Kaladan	Mi Chaung
133	Zaungtu	Built	E	17.755818	96.198980	Bago	Bago	Bago		Myit Mo Hka & Bago	Bago	Bago River
27	He Kou	MOU	P	21.341291	100.720928	Shan	He Kou			Mekong	Nam Lwe	Nam Lwe
40	Keng Tong	MOU	P	21.617799	99.500985	Shan	Mongkhak			Mekong	Nam Lwe	Nam Lwe
41	Keng Yang	MOU	P	21.346900	100.561900	Shan	He Kou			Mekong	Nam Lwe	Nam Lwe
63	Mongwa	Built	E	21.396990	100.325821	Shan	Mong Yawng	KengTung	Manlane	Mekong	Nam Lwe	Nam Lwe
112	Suo Lwe	MOU	P	21.359543	100.176054	Shan	Monghpyak	Moemeik		Mekong	Nam Lwe	Nam Lwe
72	Nam Lin	LocMoU	P	20.742516	100.241026	Shan	Tachileik	Tachileik		Mekong	Nam Lin	Nam Lin
137	Mong Hsat	LocMoU	P	20.662222	99.375000	Shan	Mong Hsat			Mekong	Nam Hkoke	Nam Hkoke
163	Nam Hkok	Identified	I	20.196337	99.346670	Shan	Mong Hsat			Mekong	Nam Hkoke	Nam Hkoke
9	Belin	LocMoU	P	17.519723	97.243546	Mon	Thaton	Bilin		Bilin	Bilin	Bilin River

ID	Hydropower Plant	HP or Multipurpose	D/S Distance to irrigation extraction if not from dam (km)		Catchment Area (km2)	Catchment Annual rainfall (mm)		GIS Rainfall	Mean annual inflow (MAF) into reservoir (m3/s)	Unit flow l/s/km2	Qmin/ MAF		Dam Type	Dam Height (m)	Full Supply Level (FSL) (m)	Low Water Level (LWL) (m)	Drawdown (m)		Reservoir Area (km2)	Total Length of reservoir (km)
165	Sar Ra Wa Chaung				1,565			2,123	72.0	46.0										
113	Taninthayi	HP			9,870	2,930		2,123	470.0	47.6	12%			-					585.0	
157	Tha Gyet Chaung				1,104			2,123	36.0	32.6										
156	Thein Kun Chaung				1,248			2,123	22.0	17.6										
158	Glohong Kra				60			2,942	2.7	45.0										
86	Nancho	HP			821	1,650		1,269	18.3	22.3	17%			72	295				0.3	3.0
96	Paung Laung (lower)	Multi	14		4,381	1,650		1,269	128.0	29.2	14%		RCC	131	225				17.0	16.0
97	Paung Laung (middle	HP			2,722	1,800		1,269	84.6	31.1	15%		RCC	110	284				9.6	10.0
98	Paung Laung (upper)	HP			2,572	1,710		1,269	82.4	32.0	14%		RCC	98	370	352	18		61.0	50.0
101	Phyu Chaung	Multi	4		1,093	2,540		2,081	36.2	33.1	10%		Rockfill	75	162				24.0	27.0
107	Shwegyin	HP			878	3,700		2,081	39.3	44.8	10%		Rockfill	57	84				58.4	35.0
151	Thauk Ye Khat 1				1,621			2,081	36.0	22.2										
120	Thauk Ye Khat 2	HP			2,175	2,692		2,081	50.5	23.2	11%		Earth	94					13.8	22.0
127	Yenwe	Multi	12.35		793			2,081	39.1	49.3	7%		Earth	77	103				76.7	36.0
8	Bawgata	HP			260			2,806	9.5	36.5	9%		Rockfill	80					19.4	
161	Than Dwe				738			2,665												
116	Thahtay	HP			1,293			2,545					Zone type/Rockfill	91	81	50	31			32.0
164	Saing Din				926			4,428												
52	Lemro 1	HP			6,535	3,560		2,750	404.0	61.8	#N/A								36.0	
54	Lemro 2	HP			8,355	3,335		2,750	530.0	63.4	#N/A								193.0	
162	Kyein Ta Li				880			2,665												
154	Mi Chaung				1,296			2,665												
133	Zaungtu	HP			1,098			3,151	57.0	51.9	7%		Embankment	45	65	52	13		14.9	18.5
27	He Kou	HP			15,103			1,381	359.0	23.8	20%								6.5	27.0
40	Keng Tong	HP			4,543			1,381	111.0	24.4	20%								8.4	26.0
41	Keng Yang	HP			14,260			1,381	340.0	23.8	20%								5.4	24.0
63	Mongwa	HP			13,800	1,535		1,381	285.0	20.7	19%		Gravity Dam	51	555	552	3		8.0	30.5
112	Suo Lwe	HP			7,315			1,381	178.0	24.3	20%			-					40.9	72.0
72	Nam Lin	HP			2,614	2,964		1,408	46.1	17.6	12%		CG	26	397					
137	Mong Hsat	HP			1,284			1,368	21.2	13.4	15%									
163	Nam Hkok				2,736			1,368	43.0	15.7										
9	Belin	HP			2,250	3,700		3,138	190.0	84.4	5%			131					310.0	

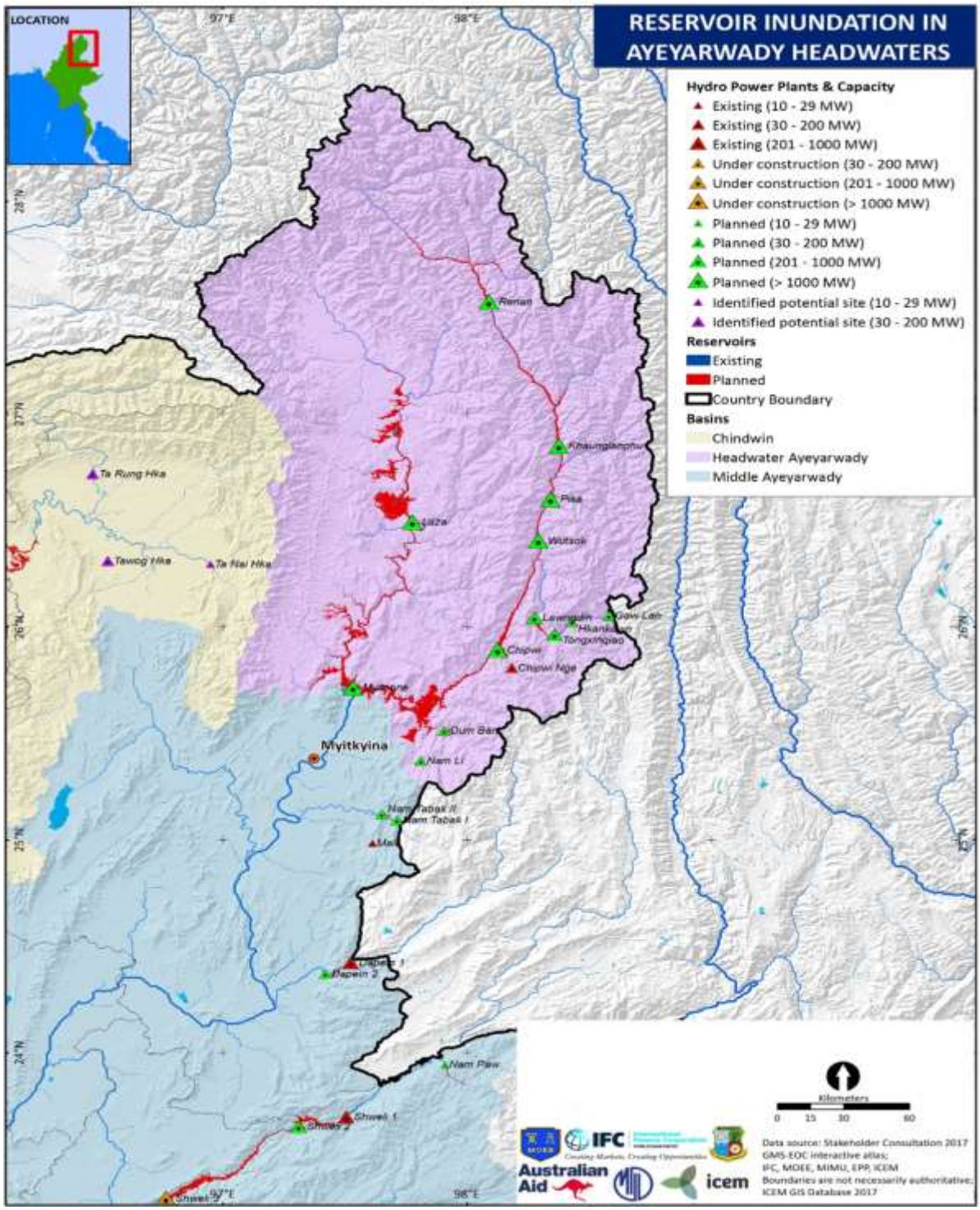
ID	Hydropower Plant	Reservoir Dead Storage (hm3)	Reservoir Live Storage (hm3)	Reservoir Total Storage (hm3)	Reservoir Retention period (days)	RoR or Storage		Distance along river between dam and powerhouse (km)	Powerhouse Type	Total Powerplant Design Discharge (m3/s)	Turbine discharge/ Min Flow	Turbine Design Head (m)	Installed Capacity (MW)	Annual Generation (GWh)	Firm Power (MW)	Plant Factor		Transmission Line Voltage level (kV)
165	Sar Ra Wa Chaung												11.0					
113	Taninthayi	18,471	8,615	27,086	212	S		-					600	3,476		0.66		230
157	Tha Gyet Chaung												20.0					
156	Thein Kun Chaung												25.0					
158	Glohong Kra												40.0					
86	Nancho	5	4	9	2	RoR		5.2	Above ground	46	14.3	100	40	152	13	0.43		230
96	Paung Laung (lower)	340	350	690	32	S		-		310	17.4	104	280	911	104	0.37		230
97	Paung Laung (middle	215	214	429	29	S		-		100	8.1	85	100	342	39	0.39		230
98	Paung Laung (upper)	426	860	1,286	121	S		-	Above ground	200	17.4	79	140	454	84	0.37		230
59	Mantong	717	498	1,215	146	S		-	River-bank	282	9.1	86	225	936	63	0.47		500
101	Phyu Chaung	52	727	780	233	S		-	Above ground				40	120	28	0.34		230
107	Shwegyin	630	1,450	2,080	427	S		-	Above ground	207	51.9	41	75	262	51	0.40		230
151	Thauk Ye Khat 1												150.0					
120	Thauk Ye Khat 2	296	148	444	34	S		-					120	604	101	0.57		230
127	Yenwe	149		149	-	RoR		-					25	123	14	0.56		33
8	Bawgata	557	278	835	339	S		-					160	500		0.36		
161	Than Dwe												39.0	105		0.31		
116	Thahtay				-	-		-	Semi-Underground	200	-	64	111	386	34	0.40		230
164	Saing Din												76.5	236		0.35		
52	Lemro 1	1,520	7,609	9,129	218	S		-					600	3,576		0.68		
54	Lemro 2	4				ROR		-					90	273		0.35		
162	Kyein Ta Li												28.0	151		0.62		
154	Mi Chaung												200.0					
133	Zaungtu	105	302	407	61	S		-					20	76	9	0.43		66
27	He Kou	56	12	68	0	RoR		-					138	483		0.40		
40	Keng Tong	21	12	32	1	RoR		-					170	536		0.36		
41	Keng Yang	33	8	41	0	RoR		-					70	155		0.25		
63	Mongwa	56	22	78	1	RoR		-	Riverbed type	294	5.3	26	66	330		0.57		
112	Suo Lwe	624	714	1,338	46	S							240			-		
72	Nam Lin	2	12	14	3	RoR		-	Riverbed	304	53.0	14	36	156	15	0.49		132
137	Mong Hsat							-					30					
163	Nam Hkok												30.0					
9	Belin	220	9,491	9,711	578	S		-					280			-		230

ID	Hydropower Plant	TL Length (km)	TL Connected to S/S	Developer	Country	Investment by	Installed Capacity (MW)	Myanmar Selfuse (MW)	% use MYA	Export (MW)	Export to	Estimated No. Construction Workers (planned projects)	Camp followers X2
165	Sar Ra Wa Chaung			NA	NA	NA						50	100
113	Taninthayi	32	Dawei	Italian-Thai	Thailand	Foreign JV/BOT	600					2,400	4,800
157	Tha Gyet Chaung			NA	NA	NA						100	200
156	Thein Kun Chaung			NA	NA	NA						100	200
158	Glohong Kra			NA	NA	NA						200	400
86	Nancho	26.52+12.5	Upper Paunglaung	MoEE	Myanmar	Sole Investment	40	40	100%	-			
96	Paung Laung (lower)	13	Pyinmana	MoEE/MOALI	Myanmar	Sole Investment	280	280	100%	-			
97	Paung Laung (middle	8	Bluchaung2-Shwemyo In/out	Energized Myanmar	SIN	Foreign JV/BOT	100	100	100%	-		400	800
98	Paung Laung (upper)	27	Nancho	MoEE	Myanmar	Sole Investment	140	140	100%	-			
59	Mantong	105	Theinni	HydroChina/IGOEC	PRC/MYA	Foreign JV/BOT	225	113	50%	113	PRC	900	1,800
101	Phyu Chaung	8	Taungoo-Tharyargone In/out	MoEE/MOALI	Myanmar	Sole Investment	40	40	100%	-			
107	Shwegyin	41	Tharyargone	MoEE	Myanmar	Sole Investment	75	75	100%	-			
151	Thauk Ye Khat 1			NA	NA	NA						600	1200
120	Thauk Ye Khat 2	23	Taungoo	Gold Energy	Myanmar	Local BOT	120	120	100%	-			
127	Yenwe	27	Tharyargone	MoEE/MOALI	Myanmar	Sole Investment	25	25	100%	-			
8	Bawgata			Thoolei	Myanmar	Local BOT	160	160	100%	-		700	1,400
161	Than Dwe			NA	NA	NA						200	400
116	Thahtay	9	Oakshitpin-Toungup In/out	MoEE	Myanmar	Sole Investment	111	111	100%	-			
164	Saing Din			NA	NA	NA	77					300	600
52	Lemro 1			Tractabel	France	Foreign JV/BOT	600	600	100%	-		2,400	4,800
54	Lemro 2			Tractabel	France	Foreign JV/BOT	90	90	100%	-		400	800
162	Kyein Ta Li			NA	NA	NA						100	200
154	Mi Chaung			NA	NA	NA						800	1600
133	Zaungtu	73	Kamarnat	MoEE	Myanmar	Sole Investment	20	20	100%	-			
27	He Kou			YNIC	PRC	Foreign JV/BOT	138	69	50%	69	<-PRC?	600	1,200
40	Keng Tong			YNIC	PRC	Foreign JV/BOT	170	85	50%	85	<-PRC?	700	1,400
41	Keng Yang			YNIC	PRC	Foreign JV/BOT	70	35	50%	35	<-PRC?	300	600
63	Mongwa			ESDC	Myanmar	Local BOT	66	66	100%	-			
112	Suo Lwe			YNIC	PRC	Foreign JV/BOT	240	120	50%	120	?	1,000	2,000
72	Nam Lin	48	Tacheleik	MAM	Myanmar	Local BOT	36	36	100%	-		100	200
137	Mong Hsat			Suntac Power Co.	Myanmar	Local BOT	30	30		30		100	200
163	Nam Hkok			NA	NA	NA						100	200
9	Belin	61	Thaton	HCDG	Myanmar	Local BOT	280	280	100%	-		1,100	2,200

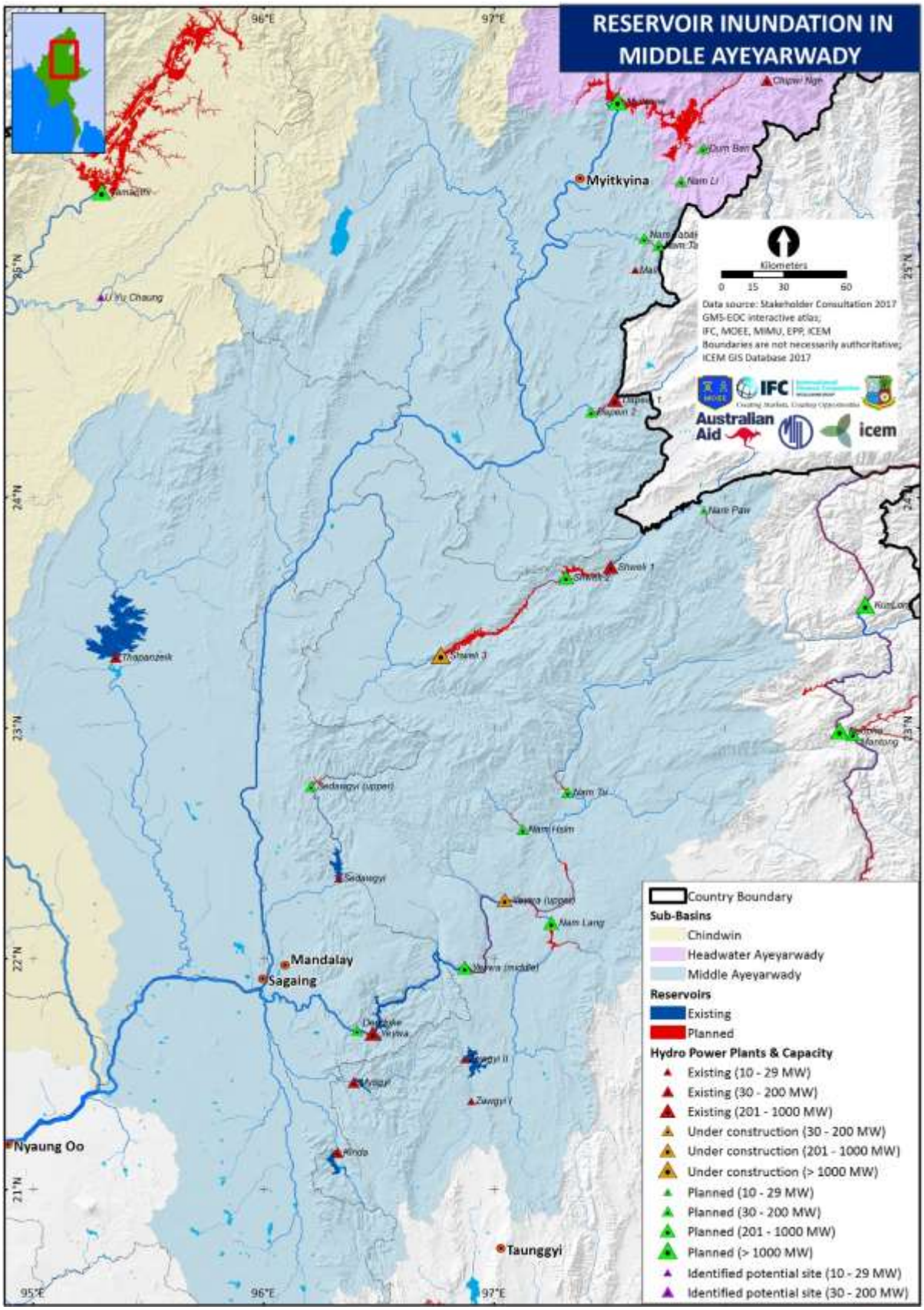
ANNEX C RESERVOIRS INUNDATION MAPS

The following reservoir inundation maps for planned hydropower projects have been developed from a digital elevation model (DEM) for Myanmar. The area represent the inundation at FSL provided to the SEA Team. It should be noted that these maps are indicative only as the coordinates for some of the proposed dams are approximate. When FSL was not available, it was estimated from dam height. One should keep in mind that reservoir areas on flat topography can result in large increases in inundated area for a small increase in elevation (e.g. Thamanthi), as opposed to reservoir areas in valleys with steep side slopes (e.g. most Thanlwin projects).

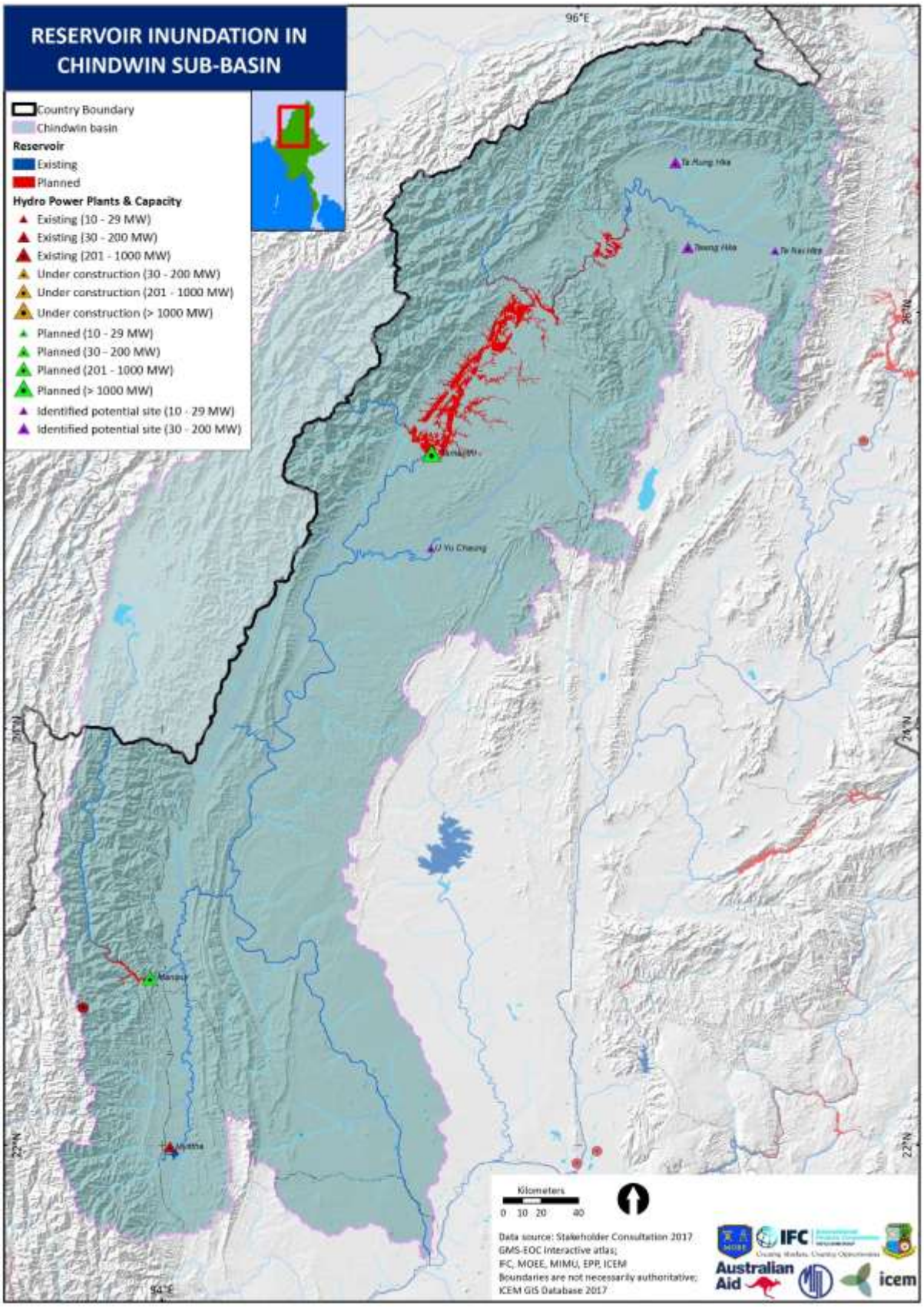
1. AYEYARWADY HEADWATERS



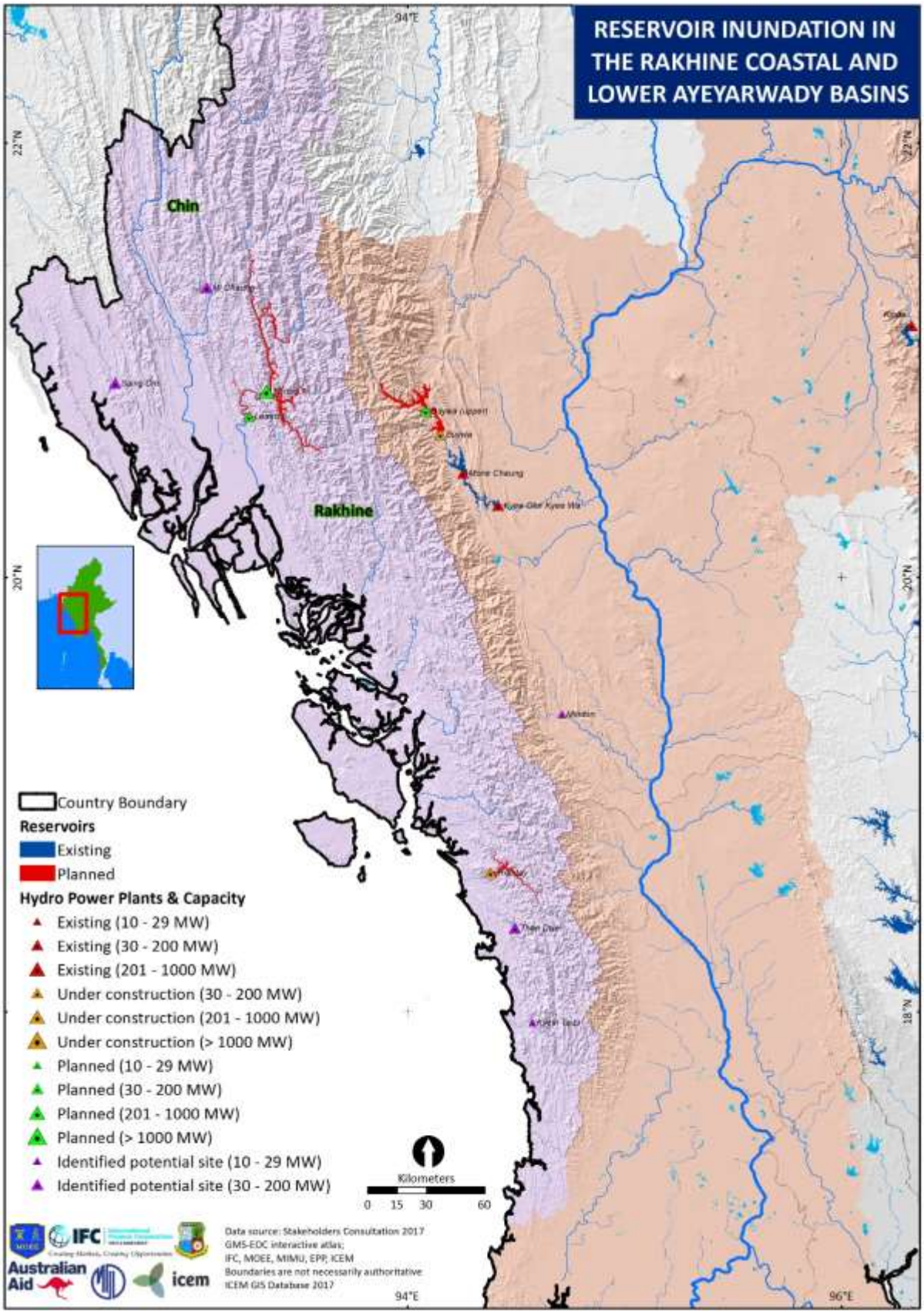
2. MIDDLE AYEYARWADY



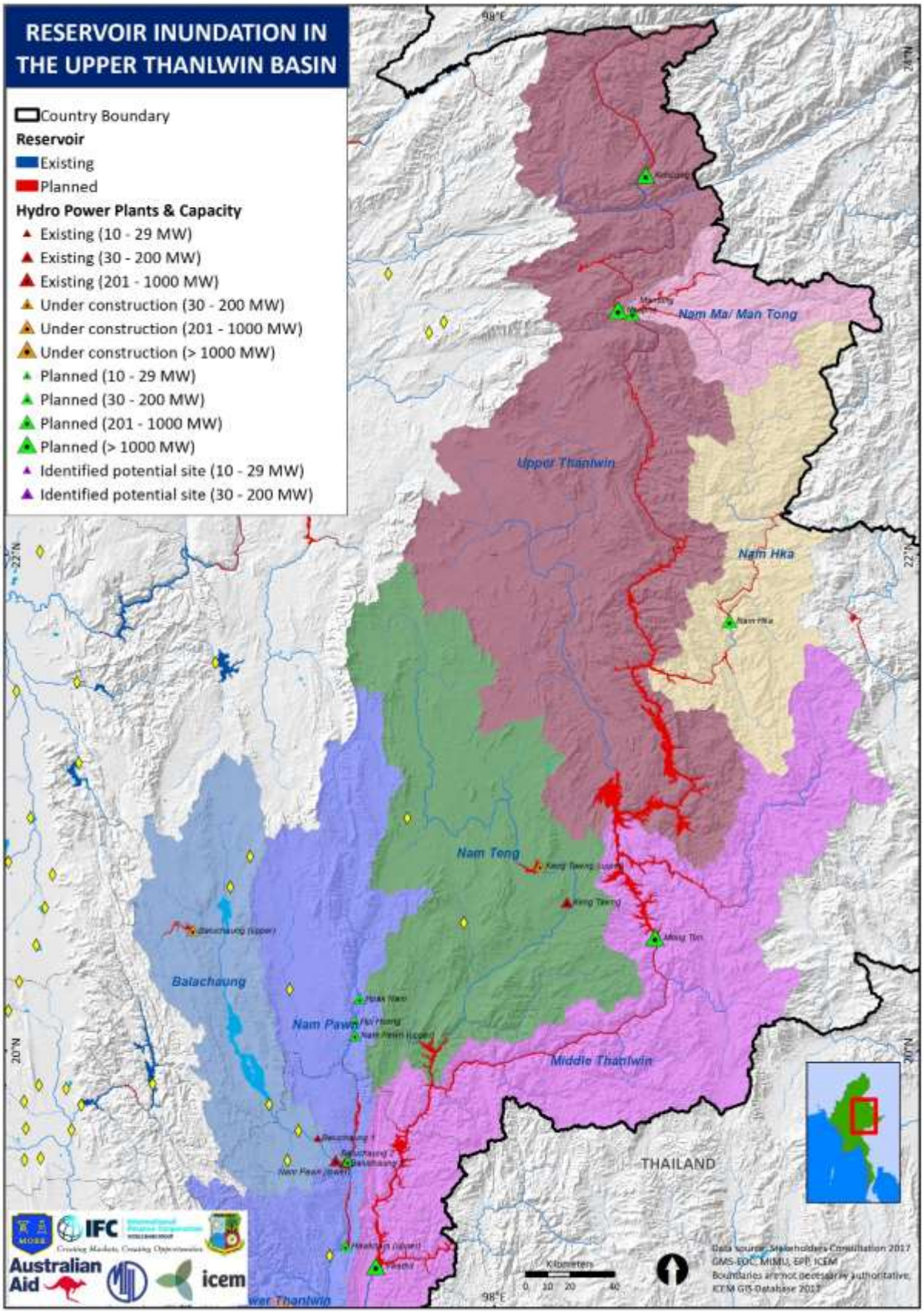
3. CHINDWIN


RESERVOIR INUNDATION IN CHINDWIN SUB-BASIN
Country Boundary
Chindwin basin
Reservoir
Existing
Planned
Hydro Power Plants & Capacity
Existing (10 - 29 MW)
Existing (30 - 200 MW)
Existing (201 - 1000 MW)
Under construction (30 - 200 MW)
Under construction (201 - 1000 MW)
Under construction (> 1000 MW)
Planned (10 - 29 MW)
Planned (30 - 200 MW)
Planned (201 - 1000 MW)
Planned (> 1000 MW)
Identified potential site (10 - 29 MW)
Identified potential site (30 - 200 MW)
96°E
94°E
28°N
26°N
24°N
22°N
Kilometers
0 10 20 40
Data source: Stakeholder Consultation 2017
GMS-EOC Interactive atlas;
IFC, MOEE, MIMU, EPP, ICEM
Boundaries are not necessarily authoritative;
ICEM GIS Database 2017
IFC
Australian Aid
icem

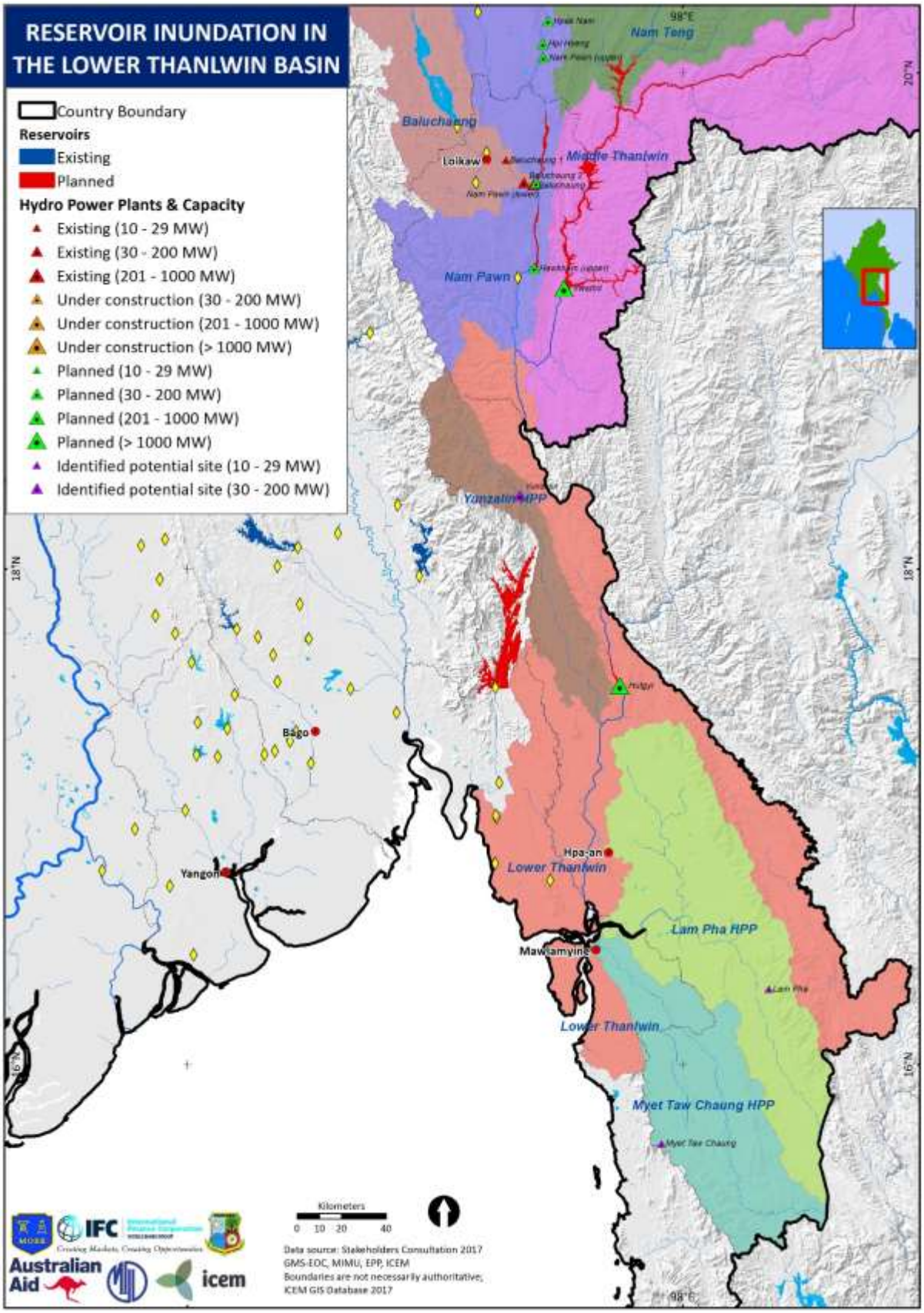
4. RAKHINE STATE BASINS AND LOWER AYEYARWADY



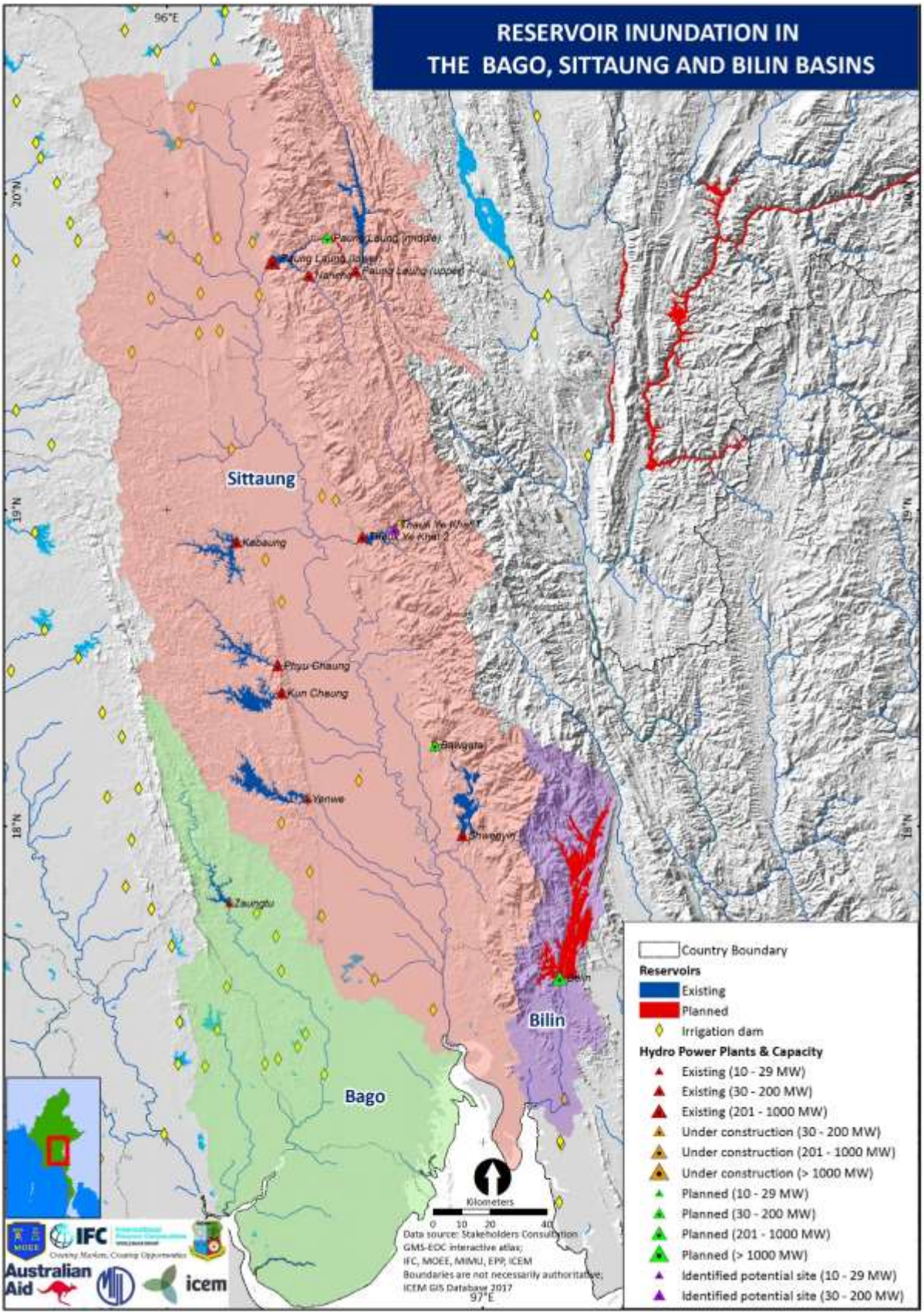
5. UPPER THANLWIN



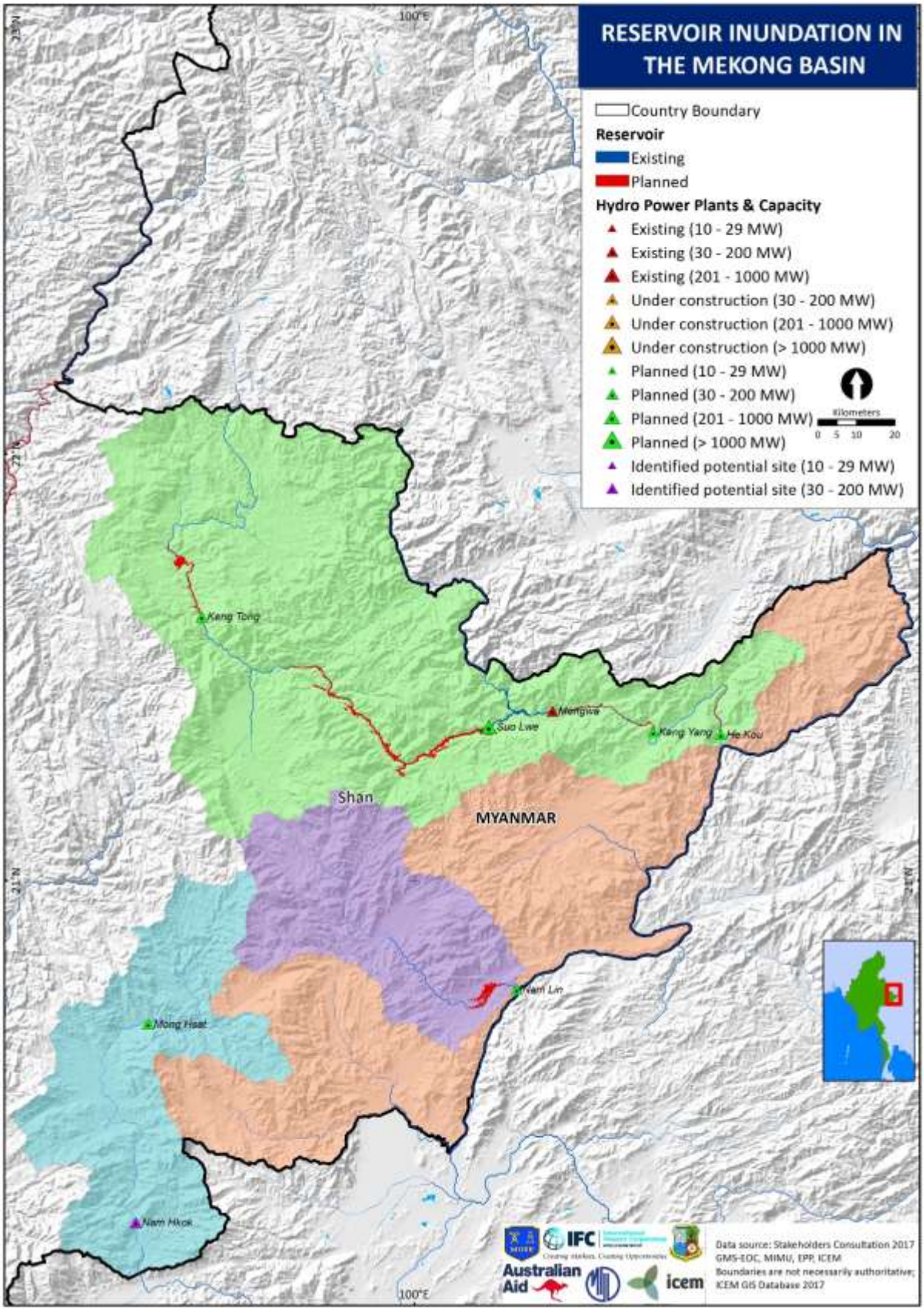
6. LOWER THANLWIN



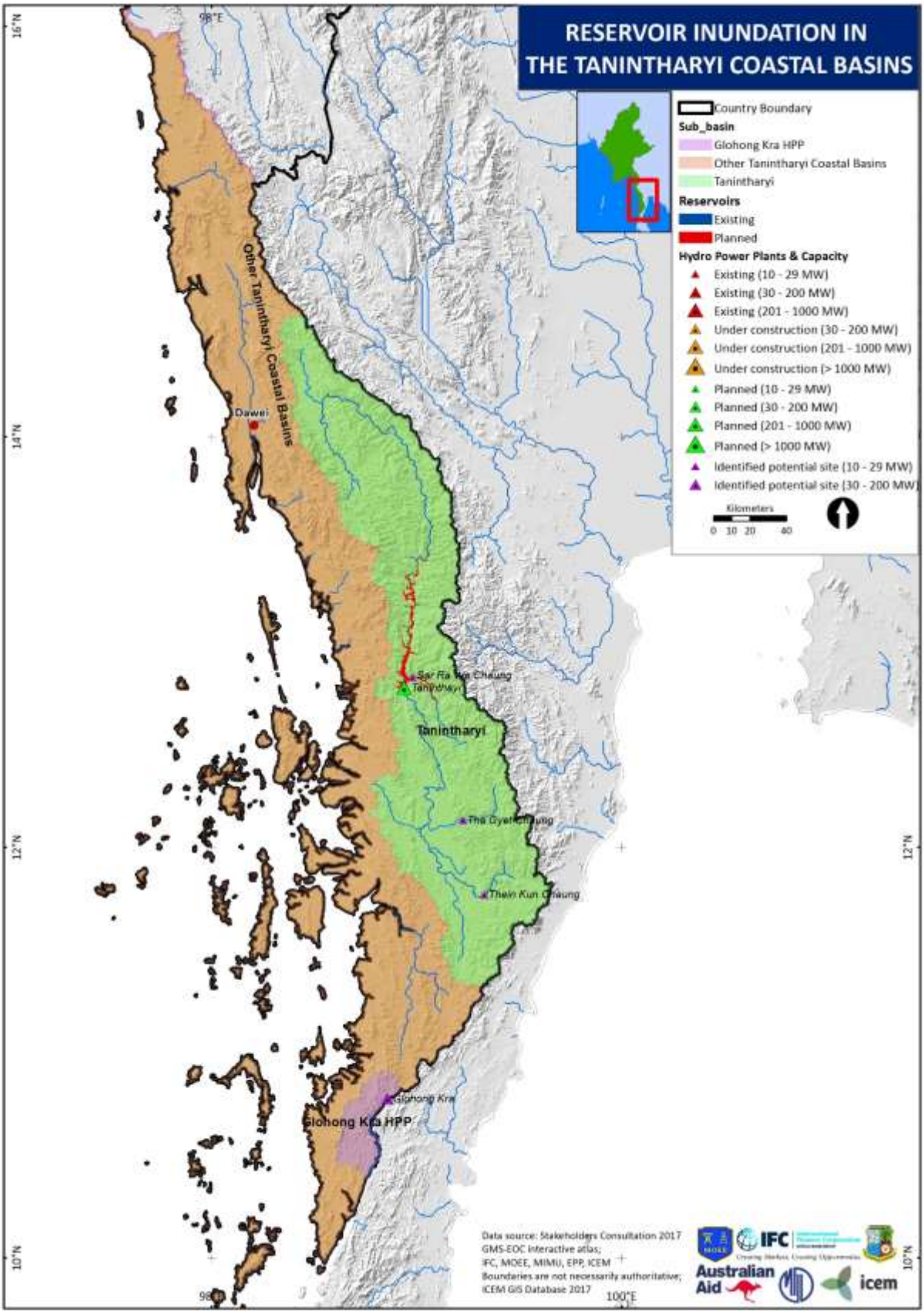
7. SITTAUNG, BELIN AND BAGO BASINS



8. MEKONG BASIN



9. TANINTHARYI REGION BASIN



IFC Myanmar Country Office:
No. 57, Pyay Road,
6 ½ miles, Hlaing Township
Yangon

www.ifc.org/hydroadvisory