Project : TA-8830-REG: Harmonizing the Greater Mekong Subregion Power Systems to Facilitate Regional Power Trade (47129-001)

Contract Number: 139061-S53235

GREATER MEKONG SUBREGION
LAOS-MYANMAR INTERCONNECTION
RPTCC-27

MILESTONE 2: SYSTEM STUDY

VIDEO CONFERENCE

THURSDAY OCTOBER 15TH, 2020

Summary

ADB TA 8830-REG: Lao PDR – Myanmar Power Interconnection Project

Activity Schedule for Technical Assessments of Lao-Myanmar interconnection validated on September 13th, 2019 in Yangon (YESC)
Consultancy Firm – Electricity De France

Key Components

Milestone 1:
Feasibility study of (i) Tachileik – Kengtung (**116.3km**) transmission line and Tachileik substation;
and
(ii) Tachileik – Kenglatt, (**75.7 km**) Transmission line

Milestone 2:
System study of high voltage power transmission systems in Myanmar and Lao PDR (230 kV, 66 kV and future 500 kV) with the objective of interconnecting the two power systems.

Milestone 3:
Assess the technical gaps and recommend options in synchronizing Myanmar power system with Lao PDR and Thailand power systems. (*Common technical standards and gaps have been already established by ADB for RPTCC*).

ADB TA 8830-REG: Lao PDR – Myanmar Power Interconnection Project

Activity Schedule for Technical Assessments of Laos-Myanmar interconnection validated on July 13th, 2019 in Yangon (YESC)

Consultancy Firm – Electricity De France

Tasks and Activities of Milestone 1

Feasibility study of (i) Tachileik – Kengtung, 116,3km transmission line and Tachileik substation; and (ii) Tachileik–Kenglatt (Border Location), 75,7km Transmission line

1. Conduct technical studies for Kengtung-Tachileik-Kenglatt transmission line development project, including proposal for initial line route using GIS mapping, and preliminary engineering design.

- Technical meeting with MEM and EDL – *13 Sep 2019*
- Prepare data collection forms and obtain data from MOEE and MEM – *Sep 2019*
- GIS Mapping and remaining data collection – *Oct 2019*
- Preliminary Engineering Design and route mapping (using PLS-CADD) – *Oct 2019*

Myanmar TF Meetings
on Oct. 18th, 2019
on Nov. 21th, 2019
on Jan. 28th, 2020

Laos TF Meetings
on Nov. 22 th, 2019
on Feb. 2nd, 2020

2. Conduct techno-economic studies of the project considering various options and confirm technical viability of the project.

- Based on validated routing and technical preliminary design, with or without options, make assessment of project cost – *End Nov 2019*
- Propose technological options including advanced technologies, voltage levels and HVAC or HVDC, smart grid components and possible future evolutions and provide recommendations – *End Dec 2019*
- Carry out risk assessment and confirm viability – End *Dec 2019*

Reports for 1 and 2

- Intermediary Report – 15 Nov 2019; **Presentation at RPTCC-26 in Hanoi on Nov, 26th, 2019**
- Presentation and obtaining comments: *28/29 Nov 2019;* **Sent to DEPP on February 20th, 2020 with 2 files for Google Earth**
- *Draft final report – Mar 2020* ***Presentation in MOEE Video Conference on March 10th, 2020***

ADB TA 8830-REG: Lao PDR – Myanmar Power Interconnection Project
Activity Schedule for Technical Assessments of Laos-Myanmar interconnection validated on July 13th, 2019 in Yangon (YESC)
Consultancy Firm – Electricity De France

Tasks and Activities of Milestone 2

Conduct system study of high voltage power transmission systems in Myanmar and Lao PDR (230 kV, ~~66~~ 132kV, 115kV and future 500 kV) with the objective of interconnecting the two power systems

3. Assess the government's power development plans including long-term generation plans and transmission system development plans and validate the project in terms of import – export volume and time frame. This task requires analysis of the two systems together with task forces appointed for MOEE (Myanmar) and MEM (Lao PDR).

3.1 Establish task forces within the two planning departments in MOEE and MEM, meetings – *13 Sep 2019* see Milestone 1
3.2 Assess Lao PDR and Myanmar generation and transmission master plans – Myanmar JICA 2014 and Laos JICA Feb. 2020
3.3 Report and Presentation

Recommend smart grid and advanced technology options

Laos TF Meetings
on Nov. 22 th, 2019
on Feb. 2nd, 2020

4. Review source of power generation, demand supply gaps in each country by region; provide report:

4.1 Data Collection – done in Milestone 1
4.2 Studies – Laos + Myanmar System Model *Oct 2019 to June 2020 – studies July - September 2020 {*
4.3 Report and presentation

Reports: September 2020

Myanmar TF Meetings
on Oct. 18th, 2019
on Nov. 21th, 2019
on Jan. 28th, 2020

Laos and Myanmar Task Forces

Data Collection for System Study by Task Forces

With Planning representatives

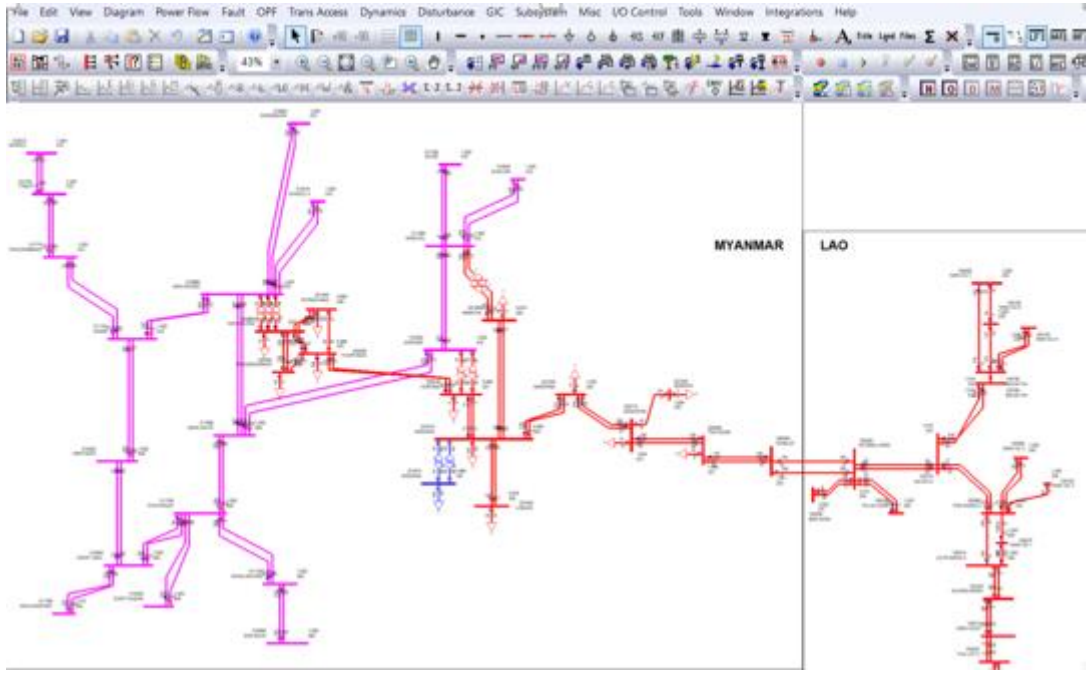
Task Force – Lao PDR

#	Name	Designation	Department	Contact No. & Email Address
1	Ms. Santisouk Phimphachanh Task force team leader – MOE)	Director	Power System Planning Division DEPP\MEM	+85620 97895289 P_santisouk@hotmail.com
2	Mr. Somsanith Sadetan	Deputy Manager	EDL	+85620 55516076 nithsadettan@yahoo.com
3	Mr. Chitpanya Panmisith	Deputy Manager	System Planning Office, EDL	+85620 23899238 Chitpanya_chit@yahoo.com
4	Mr. Soukvilay Phimmasen	Technical Officer,		+85620 23999310 Soukvilay2009@gmail.com
5	Mr. Peeza Latthasing (Alternate)	Engineer,	EDL	

Task Force – Myanmar

#	Name	Designation	Department	Contact No. & Email Address
1.	Mr. Kyaw Swa Team Leader - MOEE	Deputy Director	Department of Electric Power Planning (DEPP)	+959 250286250 kyawswa.1774@gmail.com
2.	Mr. Myo Win Zaw	Deputy Director	Department of Power Transmission and System Control (DPTSC)	+959 251182065 sedesignptp.mepe@gmail.com
3.	Ms. Yin Yin Mon	Deputy Director	Department of Power Transmission and System Control (DPTSC)	+959 250286255 yinyinmon3382@gmail.com

PSSE MODELING



PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E FRI, OCT 09 2020 14:55

	BUSES	PLANTS	MACHINES	WIND MACHINES	MACHINE OWNERS
TOTAL	913	394	401	0	401
MAXIMUM	50000	10000	12000	5600	24000

	S H U N T S			INDUCTION
	FIXED	SWITCHED	LOADS	MACHINES
TOTAL	1	135	288	0
MAXIMUM	50000	4000	100000	240

	T R A N S F O R M E R S				
	BRANCHES	TWO-WINDING	THREE-WINDING	ZERO IMPEDANCE	BRANCH OWNERS
TOTAL	1293	643	26	13	1293
MAXIMUM	100000	20000	5000	25000	200000

	MULTI-SECTION LINE				
	GROUPINGS	SECTIONS	AREAS	ZONES	OWNERS
TOTAL	0	0	5	29	19
MAXIMUM	1600	4000	1200	9999	1200

Lao & Myanmar merged PSSE files:

- 913 buses
- 1306 lines
- 669 transformers
- 401 generators
- 288 loads
- 135 switch shunts
- 29 zones

Monitored Element	%	Flow
120010 LG PA BANG 230.00 120060 PAK MONG 2 230.00 2	13,26	114,02
120010 LG PA BANG 230.00 120150 MUANG NANH 230.00 1	4,26	18,28
120010 LG PA BANG 230.00 120150 MUANG NANH 230.00 2	4,26	18,28
120010 LG PA BANG 230.00 120240 DATA-CENTER 230.00 1	37,68	122,85
120010 LG PA BANG 230.00 120240 DATA-CENTER 230.00 2	37,63	122,67
120010 LG PA BANG 230.00 120270 NAM OU 1 230.00 1	18,52	159,26
120030 PA OU DOM 230.00 120200 MUANG LONG 230.00 1	4,83	20,71
120030 PA OU DOM 230.00 120200 MUANG LONG 230.00 2	4,83	20,71
120060 PAK MONG 2 230.00 120170 NA MO 2 230.00 1	2,44	20,94
120060 PAK MONG 2 230.00 120170 NA MO 2 230.00 2	2,44	20,94
120060 PAK MONG 2 230.00 120270 NAM OU 1 230.00 1	7,20	61,95
120060 PAK MONG 2 230.00 120280 NAM OU 3 230.00 1	16,51	53,81
120060 PAK MONG 2 230.00 120280 NAM OU 3 230.00 2	16,51	53,81
120130 NAM OU 5 230.00 120190 BOUN TAI 230.00 1	18,73	61,07
120130 NAM OU 5 230.00 120190 BOUN TAI 230.00 2	18,73	61,07
120140 NAM OU 6 230.00 120190 BOUN TAI 230.00 1	28,47	122,12
120140 NAM OU 6 230.00 120290 NAM OU 7 230.00 1	5,38	23,08
120150 MUANG NANH 230.00 120310 HIEN HEUP 230.00 1	9,07	38,93
120150 MUANG NANH 230.00 120310 HIEN HEUP 230.00 2	9,07	38,93
120160 BOUN TAI 230.00 120170 NA MO 2 230.00 1	23,42	152,73
120160 BOUN TAI 230.00 120170 NA MO 2 230.00 2	23,42	152,73
120170 NA MO 2 230.00 120200 MUANG LONG 230.00 1	28,37	92,19
120170 NA MO 2 230.00 120200 MUANG LONG 230.00 2	28,37	92,19
120190 BOUN TAI 230.00 120290 NAM OU 7 230.00 1	19,98	85,72
120200 MUANG LONG 230.00 120250 BAN MOM 230.00 1	3,99	26,00
120200 MUANG LONG 230.00 120250 BAN MOM 230.00 2	3,99	26,00
120200 MUANG LONG 230.00 220950 KYINLAT 230.00 1	35,81	116,37
120200 MUANG LONG 230.00 220950 KYINLAT 230.00 2	35,81	116,37
210530 HOPONE 500.00 211260 MINEYAL 500.00 1	6,11	225,95
210530 HOPONE 500.00 211260 MINEYAL 500.00 2	6,11	225,95

Part 1: Economic Study

1.1 Assumptions: interconnection economic costs

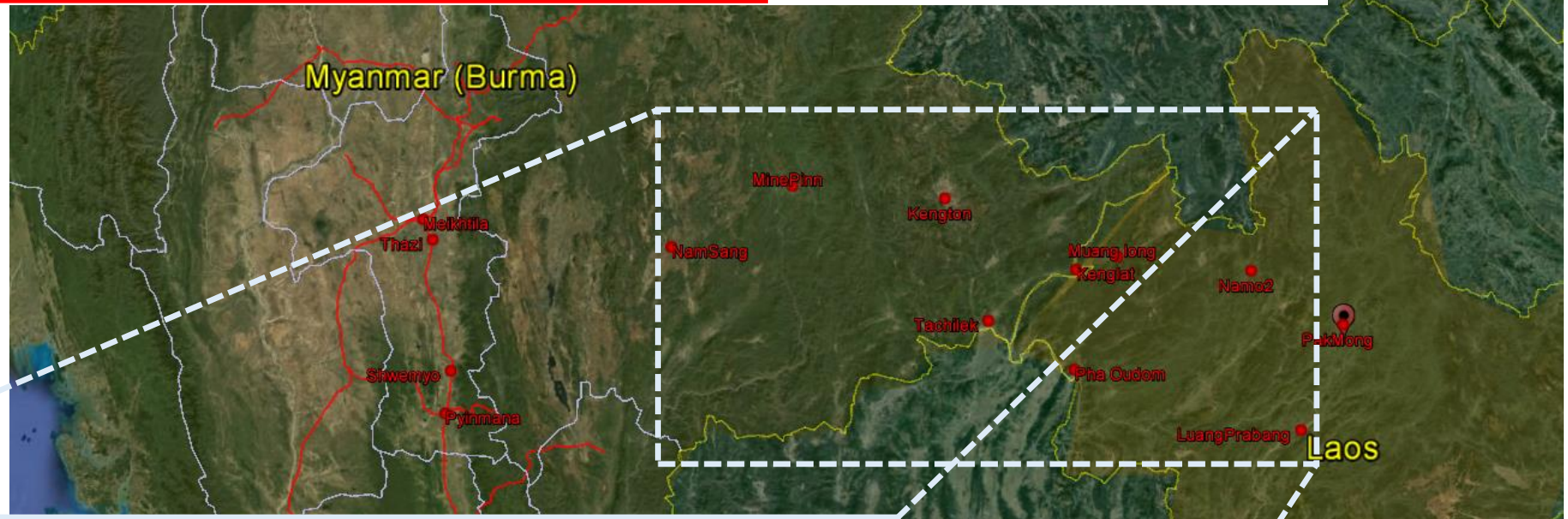
Type:

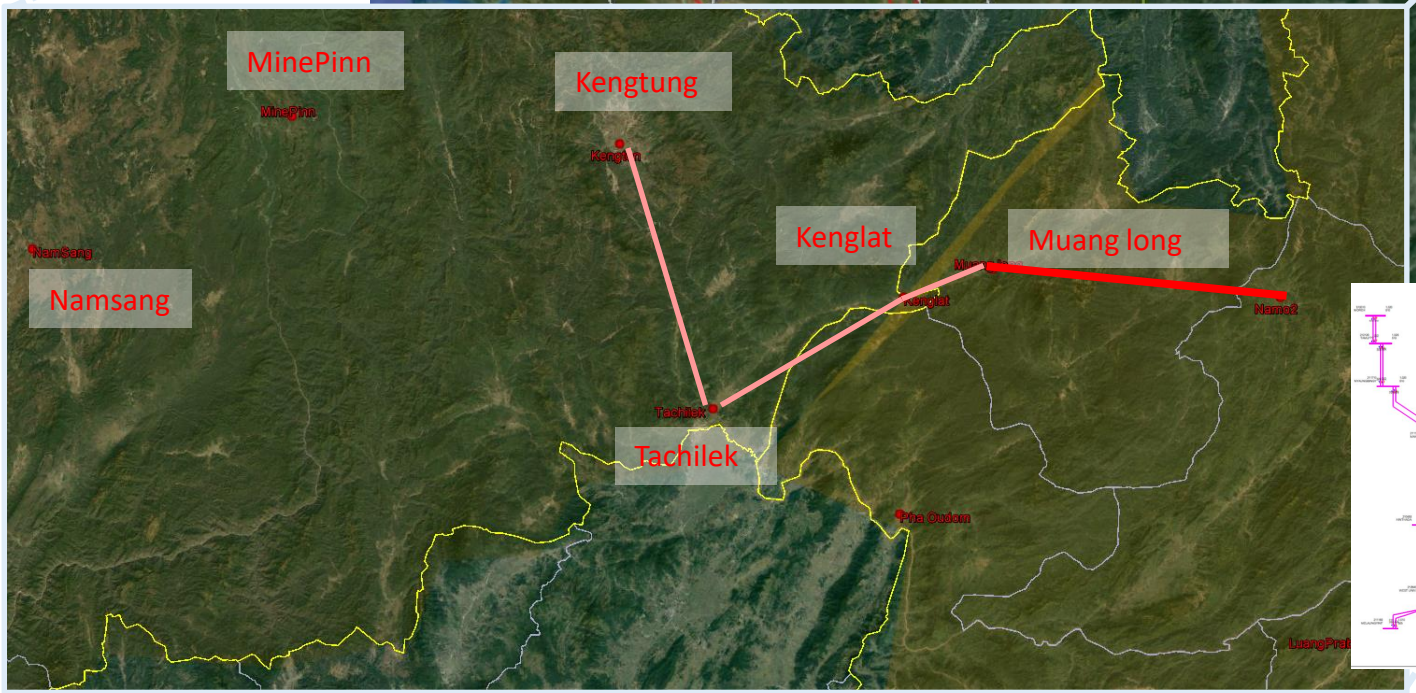
- 230 OHL from Namsan (Myanmar) to Muang Long (Laos),
- Double circuit,
- 300 km

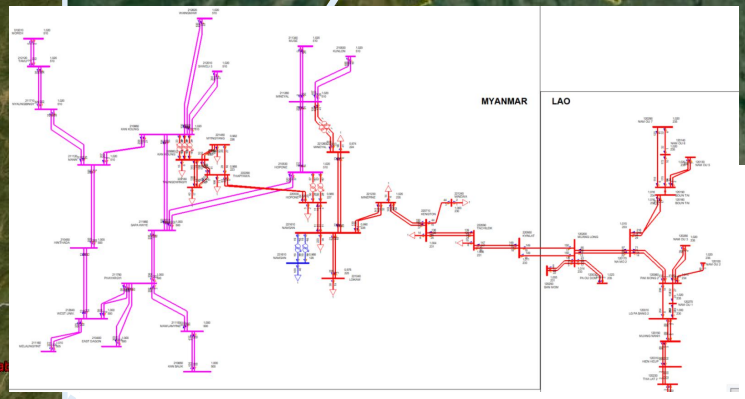
Economic assumptions:

- WACC: 7%
- CAPEX: 100 $/km/MW (230 kV)
- Economic life: 40 years

Annualized investment cost :
7.5 $/km/MW/year







1.1 Economic Generation Assumptions

Technology	CAPEX ($/kW)	Economic life (year)	Annualized investment cost ($/kW/year)	Fixed O&M cost ($/kW/year)	Variable O&M Cost ($/MWh)	Fuel Cost ($/MWh)	Annual power factor (%)
Gas Turbine	1,100	25	88.6	22.8	2	54	93%
Gas Combined Cycle	1,200	25	96.7	27.6	1	43	93%
Coal	1,800	25	135.0	30	2	15	93%
Hydropower	2,000	40	140.6	7.2	0	0	58%
Solar PV	500	25	42.9	7.2	0	0	17%

Interconnection	CAPEX ($/km/MW)	Economic life (year)	Annualized investment cost ($/km/MW/year)
Double circuit OHL	100	40	7,5

Annual power factor

- **Hydro's annual factor is based on 5 months at 70% (wet season) and 7 months at 50% (dry season) of the capacity**
- **Thermal: forced+planned outage fixed at 7%**
- **Solar PV fixed at 17%**

Sources:

- Myanmar National Electricity Master plan, Dec 2014
- JICA reports for OHL economic parameters

Gas: 7 $/MMBTU
Coal: 60 $/ton
Gas Combined cycle: Heating value=0.29 MWh/MMBTU, Efficiency=57%
Gas Turbine: Heating value=0.29 MWh/MMBTU, Efficiency=45%
Coal: Heating value=8.50 MWh/ton, Efficiency=43%
CO2 emission: 0 $/ton

1.3 Weekly Load Patterns 2018 and 2019

- Laos demand is ¼ of Myanmar demand
- Load patterns shape are similar in both system:
  - Off-peak period from December to March
  - Peak period from April to November

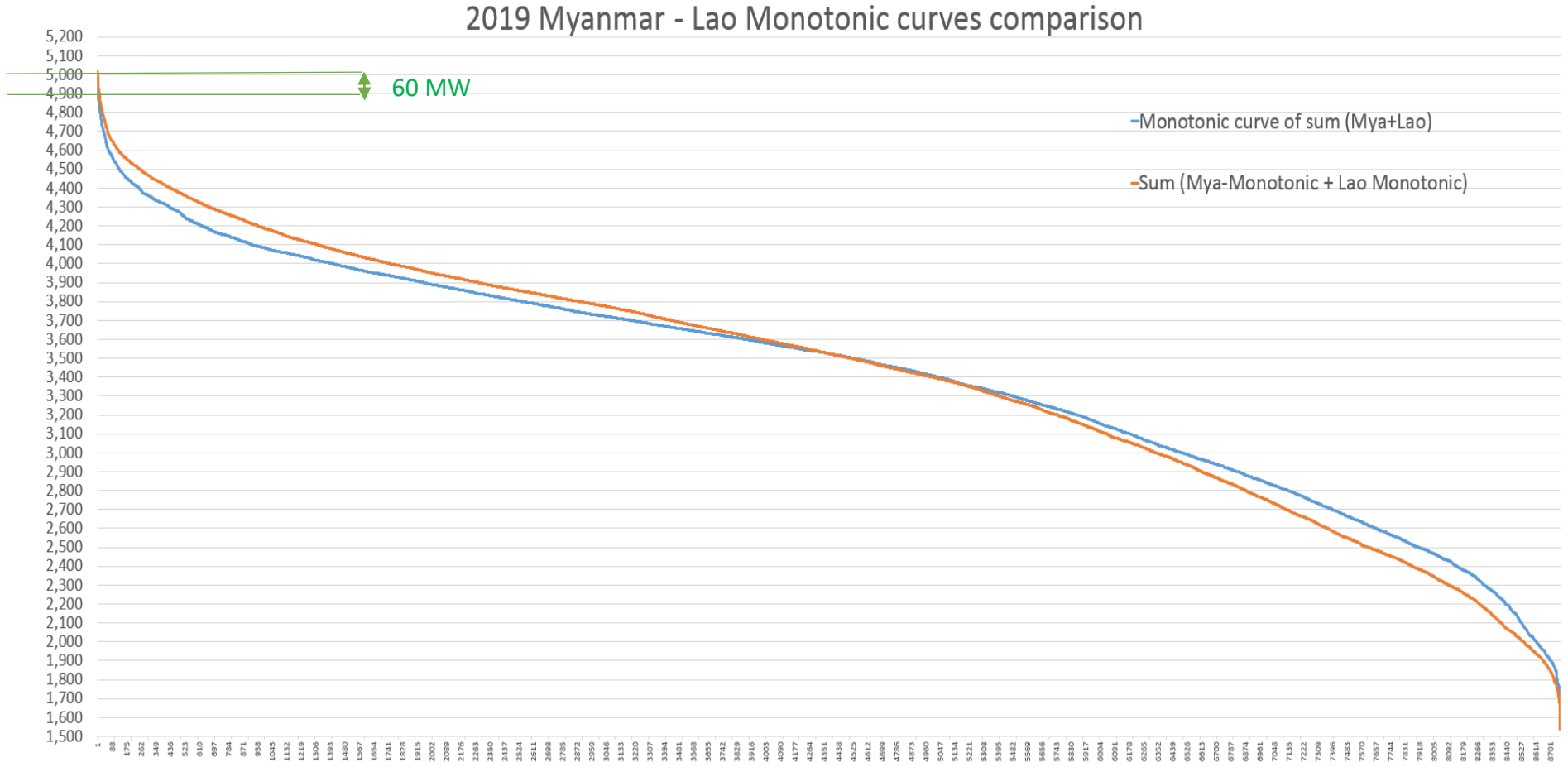
	MYANMAR			LAOS		
Country-Year	Mya-2018	Mya-2019	2018-->2019	Laos-2018	Laos-2019	2018-->2019
Annual load (TWh):	21,767	23,090	6.1%	5,444	6,779	24.5%
Peak load (MW):	3,585	3,798	5.9%	953	1,223	28.3%
Peak load (date, hour):	11/18, 17:00	11/8, 17:00		4/27, 19:00	10/28, 18:00	
Offpeak load (MW):	1,190	1300	9.2%	340	234	-31.1%
Off peak / Peak (%):	33%	34%		36%	19%	
OffPeak load (date, hour):	1/8, 2:00	12/13, 2:00		2/18, 3:00	1/2, 1:00	

- Ratio Off-Peak/Peak is similar in both system: around 34%
- Myanmar demand increased by 6% in 2019
- Laos demand increased by 25% in 2019 (+400 MW from week 38)

Week No:	Mya-2018	Mya-2019	2018-->2019
1			
2	350	384	10%
3	379	412	9%
4	370	411	11%
5	369	411	11%
6	361	414	15%
7	377	415	10%
8	376	427	14%
9	392	436	11%
10	385	439	14%
11	422	440	4%
12	414	459	11%
13	426	468	10%
14	428	475	11%
15	428	485	13%
16	396	454	15%
17	401	453	13%
18	451	497	10%
19	432	464	7%
20	440	462	5%
21	449	447	-1%
22	460	445	-3%
23	388	439	13%
24	421	442	5%
25	387	424	9%
26	425	452	6%
27	422	467	11%
28	429	437	2%
29	421	441	5%
30	420	440	5%
31	412	438	6%
32	414	438	6%
33	430	436	1%
34	426	437	3%
35	427	440	3%
36	404	441	9%
37	423	432	2%
38	447	439	-2%
39	445	464	4%
40	463	463	0%
41	461	472	2%
42	439	433	-1%
43	452	451	0%
44	404	494	22%
45	439	481	10%
46	437	448	2%
47	448	447	0%
48	415	450	9%
49	423	449	6%
50	429	427	0%
51	426	405	-5%
52	433	414	-4%
TOTAL (GWh):	21,317	22,638	6%

Week No:	Lao-2018	Lao-2019	2018-->2019
1			
2	91	86	-5%
3	91	96	5%
4	94	96	2%
5	99	91	-8%
6	90	91	2%
7	87	93	6%
8	84	92	9%
9	96	101	5%
10	100	109	10%
11	98	114	16%
12	100	115	16%
13	100	121	20%
14	102	121	18%
15	107	115	7%
16	110	121	10%
17	104	121	16%
18	116	128	11%
19	102	124	21%
20	109	121	11%
21	111	121	9%
22	108	122	13%
23	106	114	8%
24	104	121	16%
25	104	121	16%
26	111	125	12%
27	107	124	16%
28	119	123	4%
29	106	137	30%
30	100	141	41%
31	100	124	24%
32	106	125	18%
33	112	132	18%
34	105	130	24%
35	109	134	23%
36	104	125	20%
37	111	132	19%
38	115	153	33%
39	114	172	50%
40	119	170	43%
41	110	172	57%
42	108	173	60%
43	112	166	48%
44	105	171	63%
45	101	161	60%
46	108	159	47%
47	117	157	34%
48	110	160	46%
49	104	158	52%
50	108	142	32%
51	98	145	48%
52	100	161	62%
TOTAL (GWh):	5,331	6,627	24%

1.3 Monotonic Load Curves Assessment



The difference between the sum of monotonic and the monotonic of the sum is about 60 MW:

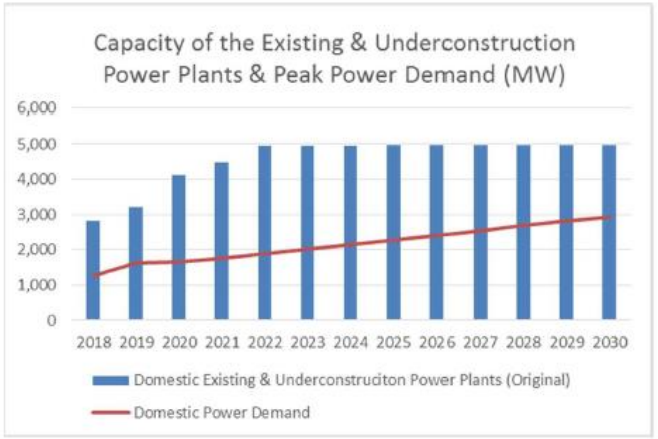
- **60 MW is the "installed capacity gain" at the peak if Laos and Myanmar were on the same cupper plate**
- **Load patterns of each country are very similar (same seasonal effect, same load type, etc.) and there is no gain from the shifted consumption patterns**
- **Others parameters could be investigate such as HPP CAPEX merit-order in each country**

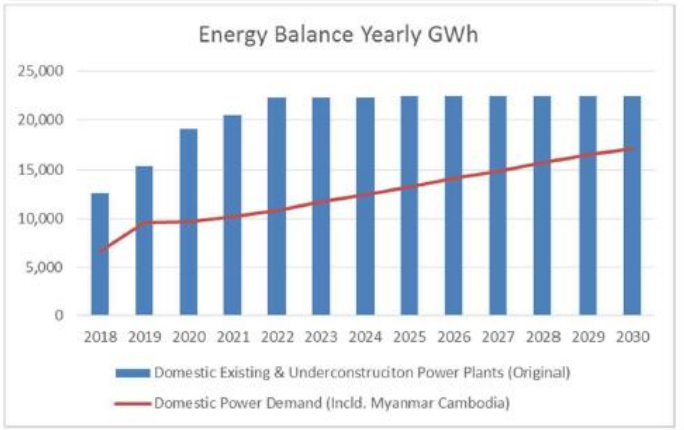
1.4 Laos and Myanmar Supply Demand Analysis

→ **2030 Lao Hydro power development plan shows additional power not necessary for local demand forecast**

→ **2030 Myanmar power development plan requires for each of the 3 scenario, adequate local power generation development to meet strong growth demand requirement**

Lao Demand-Supply forecast





Myanmar Demand-Supply forecast (NEMP 2014)

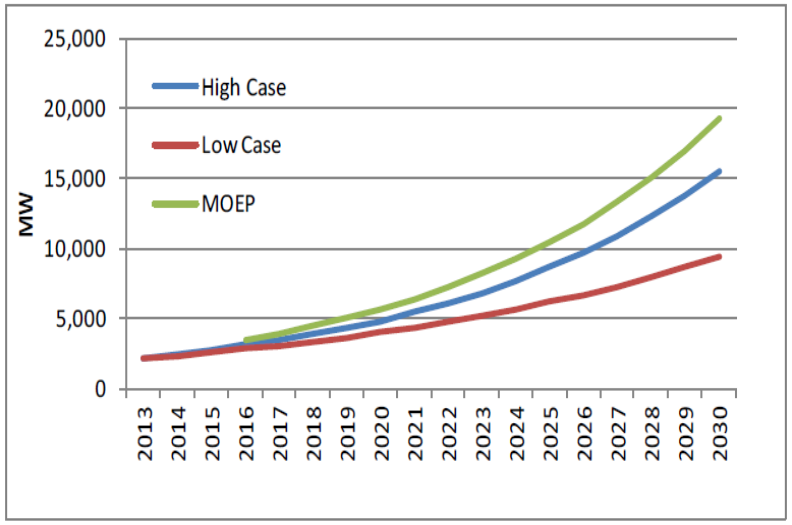
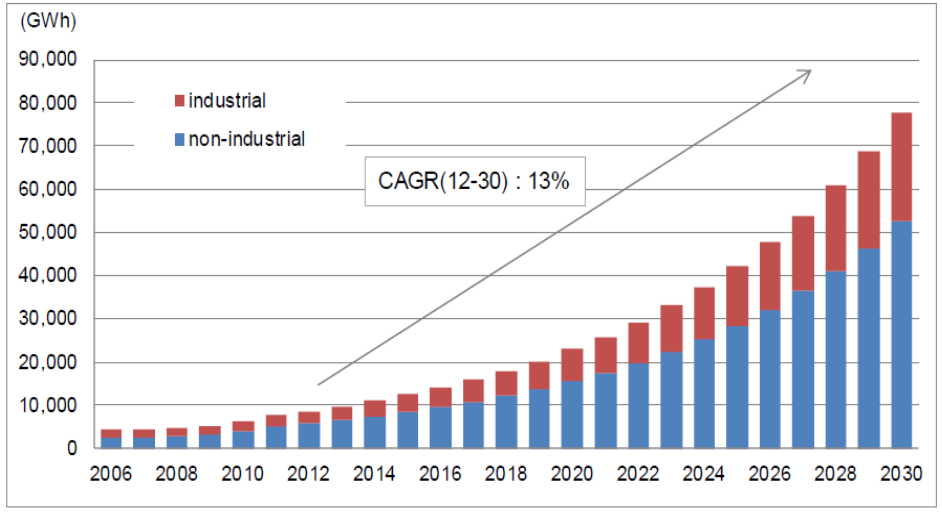


Fig. 3.3-1 Results of Demand Forecast



*CAGR=Compound Average Growth Rate

Fig.3.2-3 Power Demand (GWh, High-case) of Myanmar Separated by Sector

Sources:

- Myanmar National Electricity Master plan, Dec 2014
- Laos Master Plan February 2020

1.4 Laos Regional Supply Demand Analysis

	2020	2030
N+C1	72%	64%
C2	18%	23%
S	10%	13%

MW	Actual	Forecasting 2020												
Province	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Phongsaly	3,76	3,9	4,68	4,69	5,22	8,41	10,18	10,78	13,6	14,22	15,05	15,95	17,52	18,64
Luangnamtha	16,87	17,49	20,04	18,9	19,8	20,6	23,72	24,31	27,44	28,08	32,45	33,89	35,43	37,74
Oudomxay	13,57	14,08	20,57	19,57	20,82	22,01	22,84	27,56	31	33,43	36,75	41,5	43,87	48,9
Bokeo	27,16	28,16	32,63	30,61	31,97	33,36	36,93	39,26	42,15	43,05	44,45	47,83	49,51	51,35
Luangprabang	43,68	45,29	52,42	310,63	317,62	320,95	324,38	327,03	331,43	340,15	342,45	345,1	350,28	359,57
Xayaburi	55,21	57,25	64,3	58,86	59,6	55,64	57,41	58,13	59,65	60,55	61,66	62,89	64,31	68,77
Vientaine.Cap	455,54	472,34	535,06	503,13	533,87	561,8	584,25	606,53	622,77	639,66	665,07	699,57	732,31	772,78
Huaphan	9,5	9,85	11,47	10,95	11,62	16,27	18,12	21,23	23,96	26,79	29,84	32,91	36,05	39,39
Xiengkhuang	14,07	14,59	16,96	18,73	24,84	30,87	36,46	41,96	46,41	51,04	56,05	61,04	66,1	74,7
Vientiane.Pro	87,41	90,63	103,24	108,91	118,18	127,45	138,98	145,5	161,93	177,31	190,4	202,43	214,9	221,26
Xaysomboun	77,86	80,73	84,76	75,4	74,72	74	72,66	71,53	69,4	67,98	67,34	66,82	66,52	66,44
Borikhamxay	115,53	119,79	134,19	123,74	127,09	134,4	139,01	143,9	146,52	151,57	158,18	167,3	176,8	181,71
Khammuan	62,47	64,78	74,89	73,33	87,63	103,93	125,43	145,53	162,85	184,89	208,54	229,25	251,89	264,73
Savanakhet	84,82	87,95	99,25	95,58	107,59	119,63	133,12	146,85	159,37	172,12	178,43	185,5	193,64	203,01
Saravanh	20,73	21,5	25,27	24,38	26,08	27,89	29,41	33,62	36,02	39,93	44,28	49,91	56,88	60,67
Sekong	6,34	6,58	7,72	7,44	8,1	8,68	9,12	13,41	16,12	18,85	21,72	25,76	29,81	30,91
Champasak	99,28	102,95	118,51	111,75	121,36	129,83	135,32	144,71	151,95	160,39	170,54	180,16	189,23	198,99
Attapue	23,18	24,04	27,74	26,12	27,51	28,7	33,54	37,03	43,53	46,49	51,08	52,78	59,24	66,36
Total	**1 216,98**	**1 261,90**	**1 433,70**	**1 622,72**	**1 723,62**	**1 824,42**	**1 930,88**	**2 038,87**	**2 146,10**	**2 256,50**	**2 374,28**	**2 500,59**	**2 634,29**	**2 765,92**
Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
MW	**1 216,98**	**1 261,90**	**1 433,70**	**1 622,72**	**1 723,62**	**1 824,42**	**1 930,88**	**2 038,87**	**2 146,10**	**2 256,50**	**2 374,28**	**2 500,59**	**2 634,29**	**2 765,92**
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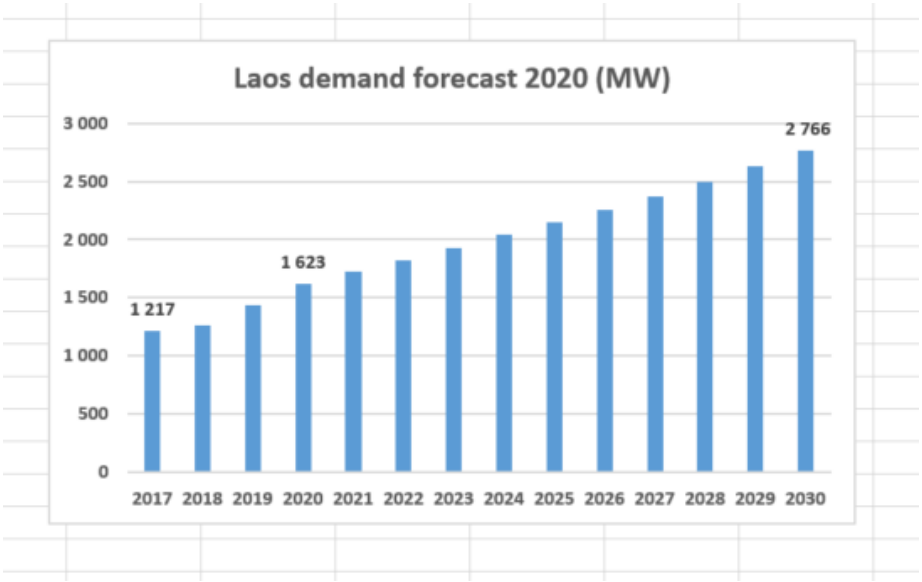


1.4 Regional Supply-Demand analysis
Myanmar States Sub-totals

→ Regions with installed power capacity below peak demand are far from Lao border
→ Regions with excess of hydro capacity are between Lao border and large Myanmar load centers

PSSE Model

MYANMAR	Peak Wet				Peak Dry				Offpeak			
State	Generation	Load	Losses	Balance	Generation	Load	Losses	Balance	Generation	Load	Losses	Balance
AYEYARWADY	1705	526	25	**1155**	1952	526	29	**1398**	338	184	2	**153**
BAGO	389	970	47	**-628**	318	970	23	**-675**	159	340	18	**-199**
KACHIN	626	114	8	**504**	447	114	4	**329**	268	40	2	**227**
KAYAH	195	56	1	**138**	139	56	0	**83**	84	20	0	**64**
KAYIN	0	191	4	**-195**	0	191	3	**-194**	0	67	1	**-67**
MAGWAY	146	532	24	**-411**	199	532	12	**-345**	45	186	10	**-151**
MANDALAY	1964	2077	71	**-185**	1821	2077	47	**-303**	695	727	14	**-46**
MON	388	312	13	**63**	502	312	17	**173**	71	109	1	**-39**
NAYPYITAW	428	770	5	**-347**	306	770	4	**-468**	184	269	2	**-87**
RAKHINE	730	181	22	**527**	693	181	16	**496**	263	63	7	**193**
SAGAING	564	1031	49	**-516**	557	1031	45	**-519**	550	361	25	**164**
SHAN EAST	46	60	16	**-30**	33	60	9	**-36**	20	21	18	**-19**
SHAN NORTH	1401	401	25	**974**	1001	401	14	**586**	600	140	5	**455**
SHAN SOUTH	1195	358	14	**823**	888	358	8	**522**	581	125	10	**445**
TANINTHARYI	1473	469	14	**991**	1671	469	19	**1183**	391	164	1	**225**
YANGON	3282	6376	69	**-3163**	3982	6376	65	**-2459**	627	2232	11	**-1615**
TOTALS (MW)	14531	14424	407	-300	14508	14424	315	-230	4875	5048	126	-300

Myanmar's largest load center Yangon accounts for 45% of domestic demand

In Shan State, Power (mostly Hydro) >>Demand

Main Grid is able to wheel power to Yangon including additional 300MW

More Hydro Power reduces Thermal Power of Myanmar

Consequently, Hydro Power helps to reduce Myanmar CO2 emissions

Myanmar regional supply-demand situation

1.5 Conclusion on Economic Study

Myanmar power fleet is composed of Gas turbine, Gas Combine Cycle, Coal, Hydro and Solar PV

Gas Turbine
Gas Combined Cycle
Coal
Hydropower
Solar PV

Coal, Gas Combined Cycle and Gas turbine are much more expensive than hydro HPP :

- **100 MW installed Hydro PP generate 511 GWh/year of energy for a yearly cost of 15.7 $/year**
- **511 GWh generated power is obtain with 62.7 GW of Coal at a cost of 20.2 $/year**
- **511 GWh generated power is obtain with 62.7 GW of GCC at a cost of 30.7 $/year**

For 100 MW capacity, Laos HPP connected to Myanmar network represent an extra-cost of 0.23 M$/year (+1.5%) compare to Myanmar HPP

- **100MW capacity of a 300 km of double-circuit OHL Myanmar-Laos has a yearly cost of 0.23 M$/year**
- **This extra-cost of 0.23M$/year extra-cost represent +1.5% of 100MW Myanmar HPP yearly cost**
- **HPP CAPEX competition between Laos and Myanmar can drive the decision to invest in Laos HPP instead of Myanmar HPP**

	Capacity (MW)	**Generating power** (GWh/year)	**Annualized investment cost** (M$/year)	**O&M cost** (M$/year)	**Fuel Cost** (M$/year)	**Yearly Cost** (M$/year)	**Yearly cost gap** (%)
Gas Turbine	62.7	511	5.9	2.5	27.6	**36.0**	129%
Gas Combined Cycle	62.7	511	6.5	2.3	22.0	**30.7**	95%
Coal	62.7	511	9.7	2.9	7.7	**20.2**	29%
Hydropower	100	511	15.0	0.7	0.0	**15.7**	0
Solar PV	343	511	14.7	2.5	0.0	**17.2**	9%

Interconnection	**Capacity** (MW)	**length** (km)				**Yearly Cost** (M$/year)	
470km double circuit OHL	100	300				0.23	

Load patterns of both country are very similar and there is no gain from the shifted consumption patterns:

- **The difference between the sum of monotonic and the monotonic of the sum is about 60 MW: It represent the "installed capacity gain" at the peak if Laos and Myanmar were on the same cupper plate**
- **Others parameters could be investigate such as HPP CAPEX merit-order in both countries**

Part 2: System Study

2.1 Assumptions: Generation Capacities

- **Laos 2030 (In MW, Northern & Central 1 regions only)**

Hydro	3 875	84%
Coal	748	16%
TOTAL	4 622	100%

Source: Laos Task Force

- **Myanmar 2030 (In MW)**

Hydro	8916	45%
CCGT	8 612	44%
OCGT	1 281	7%
Coal	660	3%
PV	170	1%
TOTAL	19 639	100%

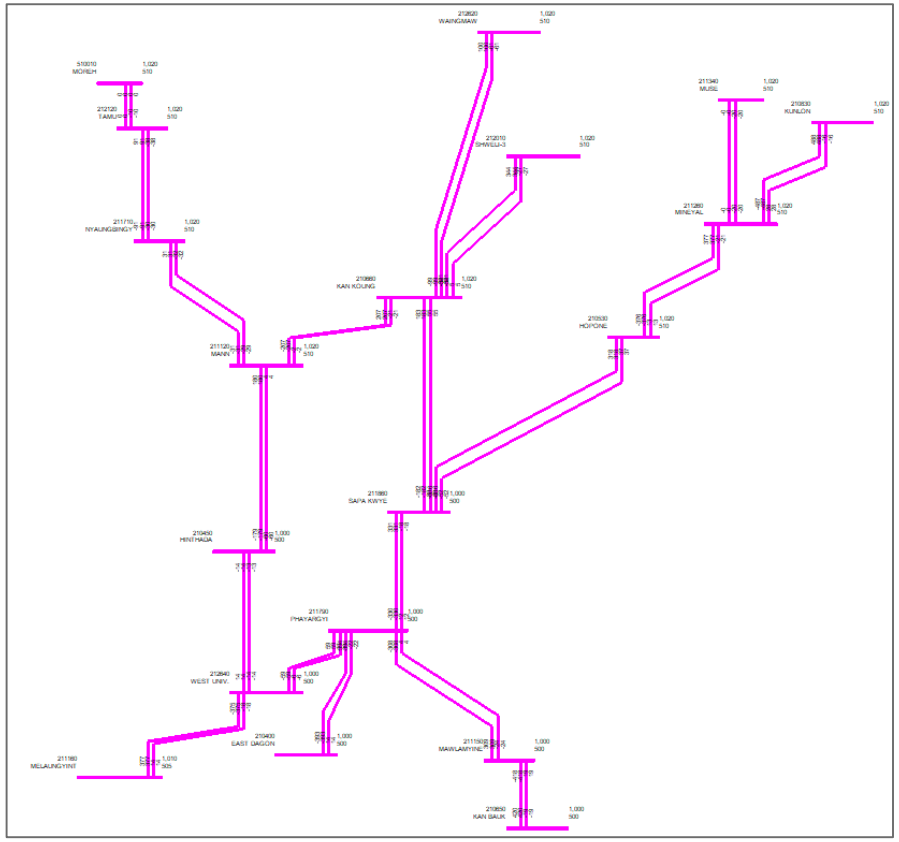
Source: Myanmar Task Force

2.1 Assumptions: Substation & Line Routing

Myanmar

Source: Myanmar Task Force

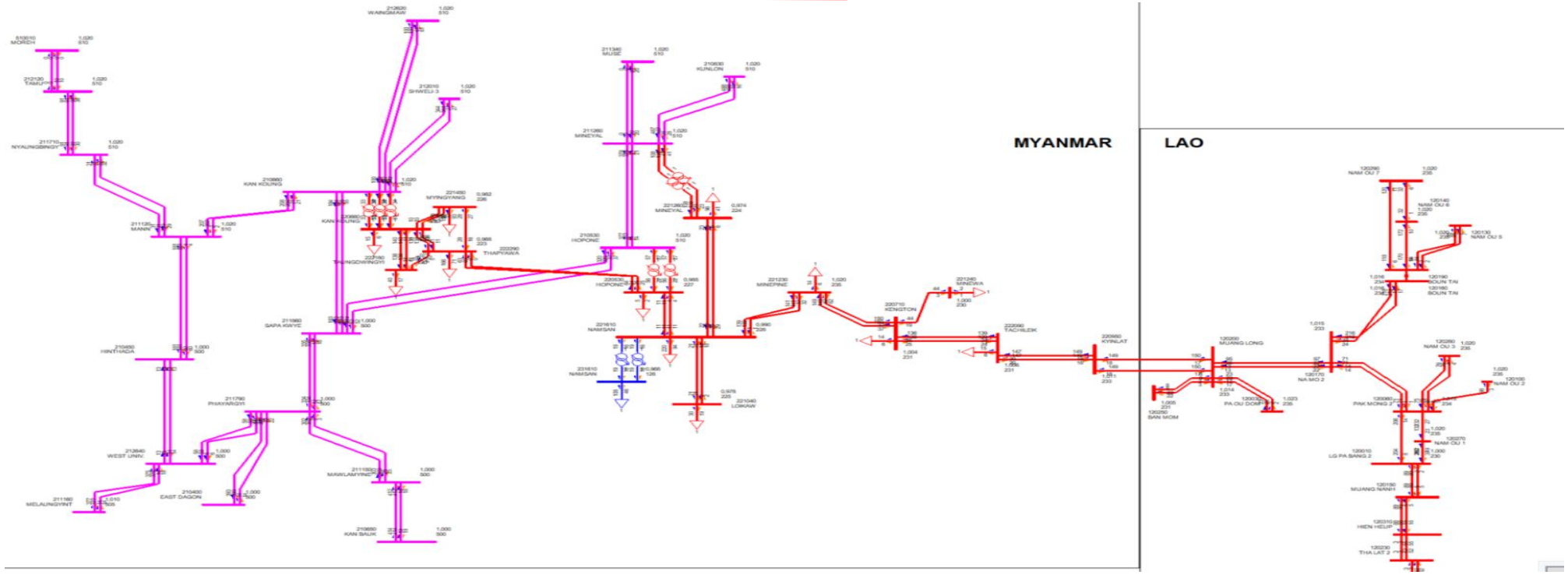
Many inconsistencies between data sources (PSSE file, Single Line Diagram, geographic map, Neplan file, Excel files) for both generation and transmission
→ No clear-cut view of future 2030 network



In PSSE:

- **500kV network topology & line length have been corrected**
- **132kV level has been entirely added**
- **Some substations have been downgraded from 500 to 230kV or from 230 to 132kV**
- **Some routings of 230kV lines have been corrected**

2.1 Assumptions: Interconnection Area



Source: Myanmar Task Force

Source: Laos Task Force

- **2 x 230 kV OHL from Namsan (Myanmar) to Muang Long (Laos). From West to East:**

Namsan > Minepine	**153km**
Minepine > Kengton	**97km**
Kengtung > Tachileik	**116km**
Tachileik > Kenglatt	**76km**
Kenglatt > Muang Long	**30km**

Total: 470km

2.1 Assumptions: Loads

For LAOS + MYANMAR

We assume a 35% off-peak load ratio based on current load patterns (Myanmar 2018 and 2019, Laos 2018 load curve)

For MYANMAR

Loads were all located on 230kV network We relocated some loads on 132kV network. Some substations still are heavily loaded (>500MW in 230kV)

Initially in provided PSSE file all the loads had 0.95 power factor. We assume:

0.92 for domestic load
0.85 for industrial load

Source: Myanmar Task Force

Source: Laos Task Force

2.2 Methodology: Study Cases

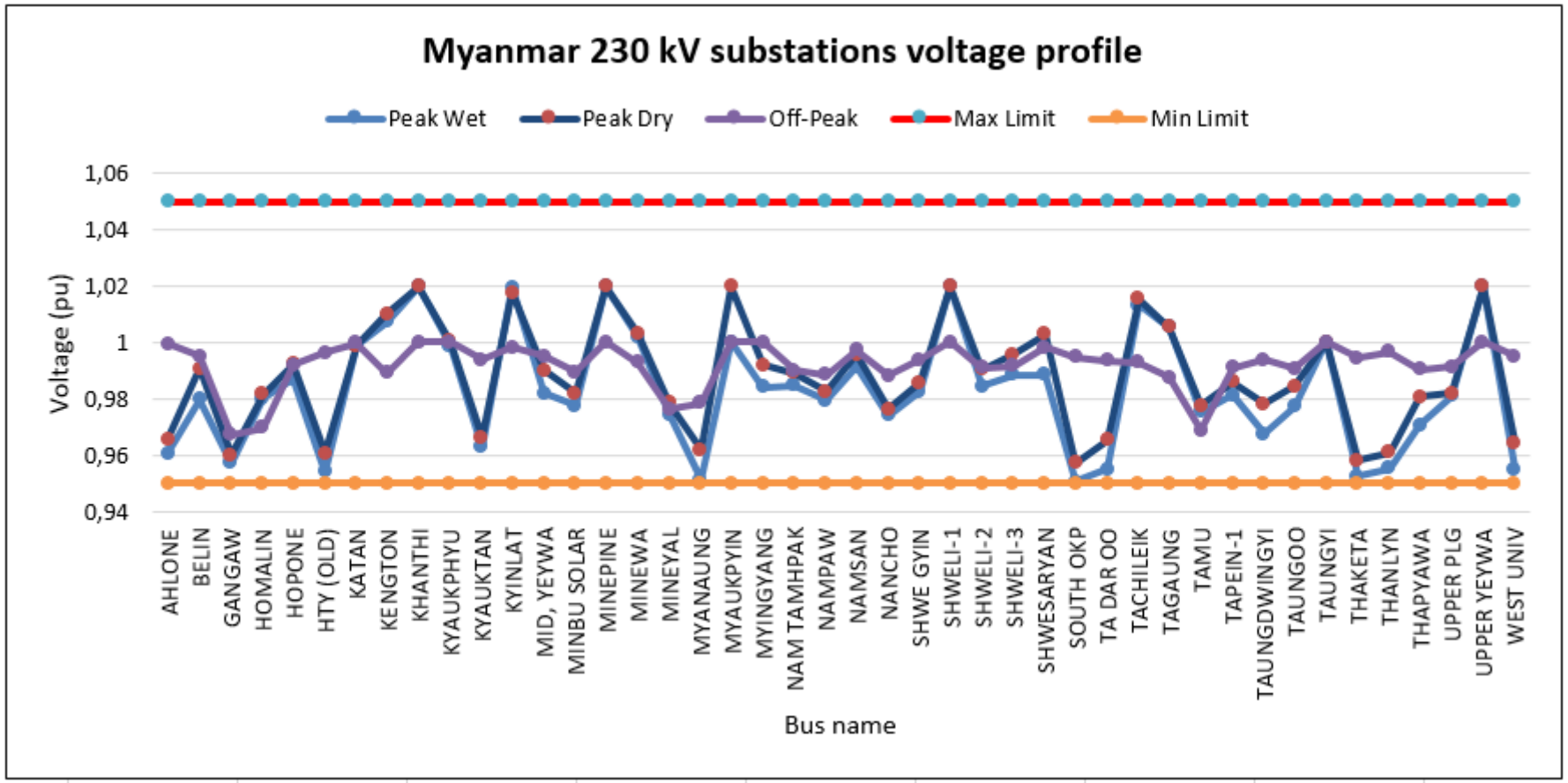
Simulation

STUDY CASE & HYPOTHESIS				
Case	Peak Wet	Peak Dry	Off-peak Wet	Off-peak Dry
Load	100%		35%	
Laos Consumption (MW)	2285		800	
Myanmar Consumption (MW)	14424		5048	
Exchange Laos -> Myanmar (MW)	300	230	300	
Laos Generation (MW)	2743	2685	1162	
Myanmar Generation (MW)	14632	14615	4800	

- **Power mixes are mainly driven by the engagement of hydro generators which is assumed to be respectively 70% of installed capacity in peak wet, 50% peak dry and 30% in off-peak regimes. The rest is covered by thermal plants.**
- **Power exchange from Laos to Myanmar is limited to 230MW in peak dry regime to ensure no more than 50% of hydro capacity is engaged.**

2.3 Steady State Analysis Results

Myanmar 230 kV substations voltage profile



2.3 Steady State Analysis Results

- No voltage nor flow issues were encountered in N & N-1 situations in interconnection area
- The interconnection has no significant impact on the power systems of both countries

2.3 Flow Assessment: Conclusions

- **In Peak Wet and Off-Peak scenarios, Laos will be able to export 300 MW to Myanmar**
- **The interconnection has no impact on lines loading.**
- **As observed in Peak Wet, Peak Dry and Off-Peak scenarios, the loading on the double-circuit lines remains below 50% (i.e no overload in N-1)**

2.3 Short Circuit Analysis

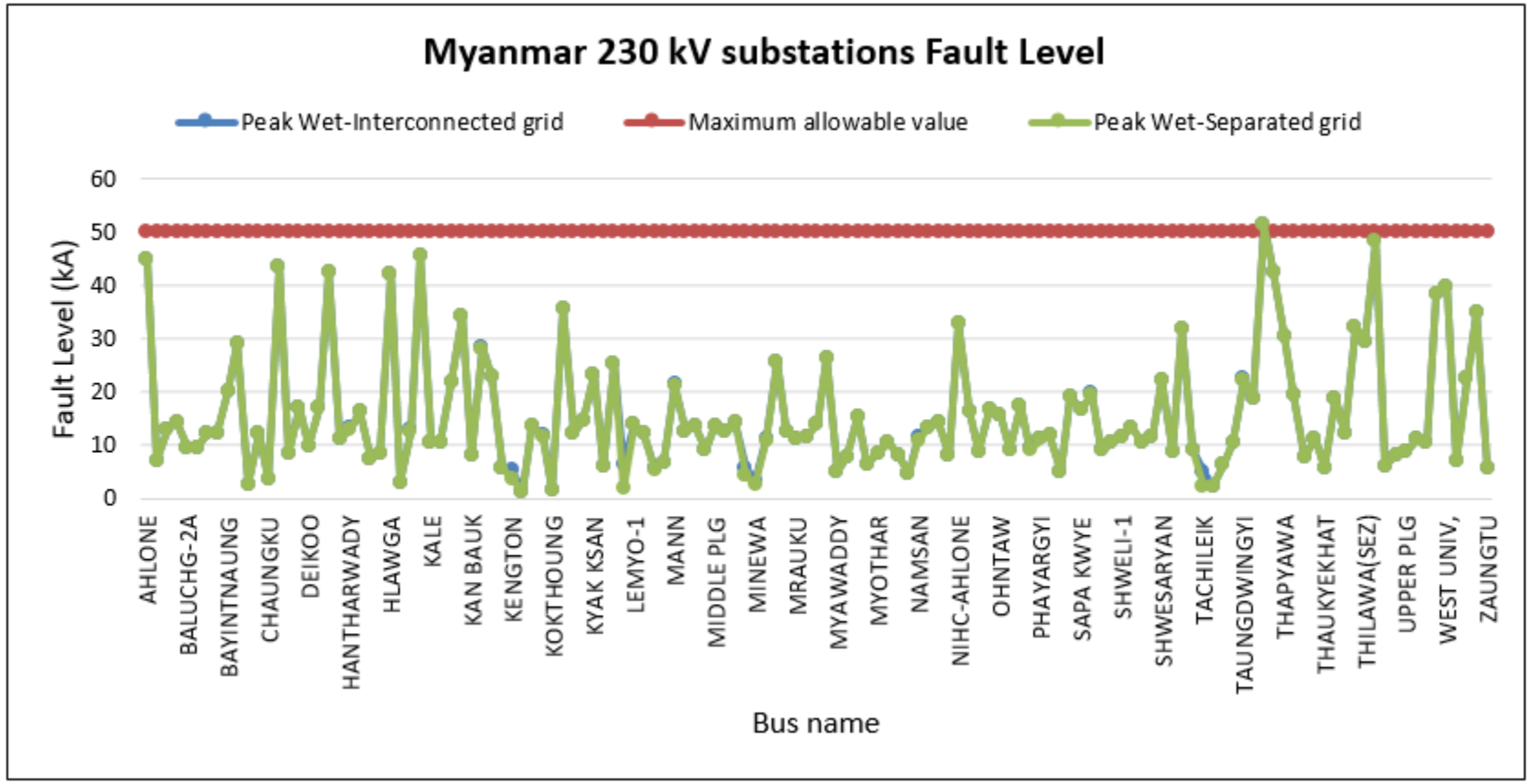
- **Methodology**
  - Voltages and phase angles were left unchanged
  - The capacitive admittances of lines, loads and shunts were left unchanged
  - Generators were modeled with sub-transient reactances
  - Calculations were applied at 115 kV, 132 kV, 230 kV and 500 kV substations
  - Short Circuit currents of interconnected and separated networks were compared for Peak Wet scenario

- **Short Circuit Criteria**
  - The maximum fault level at all substations should be less than the minimum breaker rating at the substation

Voltage Level (kV)	Maximum Allowable Fault Current (kA)
500	40 - 50
230	40 - 50
115	40
132	25 - 31.5

2.3 Short Circuit Analysis Results

Myanmar 230 kV substations Fault Level



2.3 Short Circuit Analysis: Conclusions

- **Laos network**
  - **Max Short circuit current for Laos 500 kV substations is estimated to be less than 10 kA**
  - **Max Short circuit current for Laos 230 kV substations is estimated to be less than 20 kA**
  - **Max Short circuit current for Laos 115 kV substations is estimated to be less than 25 kA**
  - **As result, it can be confirmed that short circuit current of Laos substations is estimated to be below allowable limits until 2030. In addition, the interconnection has no impact on substations fault level.**

- **Myanmar network**
  - **Max Short circuit current for Myanmar 500 kV substations is estimated to be less than 20 kA**
  - **Max Short circuit current for Myanmar 230 kV substations is estimated to be less than 50kA (only Thaketa substation reaches the limit: to be checked in operation)**
  - **Max Short circuit current for Myanmar 132 kV substations is estimated to be less than 25 kA**
  - **As result, it can be confirmed that short circuit current of Myanmar substations is estimated to be below allowable limits until 2030 for 500 kV and 132 kV.**

2.3 Voltage Management

- **Static voltage compensation will be necessary at Mine Pinn Myanmar and Muang Long Laos (around 25Mvar)**

2.4 Conclusion on System Study

- Based on data collection and CIST technical assumptions described here-before, **the building of a 230kV, 300MW double line between Laos and Myanmar:**
  - **Will reduce the load of ever over-loaded lines in Laos HV network**
  - **Won't create loading issues**

    The double-circuit lines loads remain below 50%
  - **Won't create voltage issues**

    Substation Voltages will remain between 95% and 105% of nominal voltage
  - **Won't create issues in case of short-circuit. Existing breakers will remain strong enough**

    Note: only Thaketa substation to be checked in operation
  - **Won't create issues in case of contingency:**

    Substations Voltage near the studied Laos/Myanmar interconnection will remain between 90% and 110% of nominal voltage

- For Peak Dry scenario, the studied interconnection will only be able to export from Laos to Myanmar 230MW over 300MW in order **to ensure that no more than 50% of Laos hydro capacity be engaged**

3. Conclusion on Milestone 2

- **Main similarities regarding Laos and Myanmar Systems: Generation costs, load patterns, regions weakly interconnected**

- **Main differences regarding Laos and Myanmar Systems:**
  Laos demand < < Myanmar demand
  Laos exportation capacities in the North are able to help Myanmar power needs in short/medium terms

- **No major issue for interconnecting Laos and Myanmar from Grid capacity perspective: 300MW is feasible**

- **The cost of interconnection assets will slightly affect Laos importation in Myanmar that will remain cost-effective**

- **System-to-System operation seems possible but should be proven with specific dynamic studies.**
  These studies are not possible with the current data collection.
  Without clear conclusion, a B2B in Tachileik or Muang Long should be envisaged.

Thank you for your attention