The Role of Hydropower in Myanmar

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Abstract— Myanmar has very rich hydropower resources with a total potential of around 100,000 MW. At present, about 3% of these resources have been developed. The hydropower is a renewable and clean energy source with mature technology and run-of-river type hydropower schemes can be implemented to provide continuous "base load" generation. Therefore, hydropower can substantially improve efficiency in a mixed power system and it will be able to meet the power demand for industrial development in Myanmar. According to the National Electricity Master Plan, the electricity consumption in 2015 was 2527 MW, and the forecasted demand for 2020, 2025 and 2030 is 4530 MW, 8121 MW and 14542 MW respectively.

Myanmar's hydropower sector has been developed since 1990s.The share of contribution of hydropower to electricity production has grown and the hydroelectric power supply has become a majority of all the electricity consumed in Myanmar. At present, 27 hydropower stations with the total installed capacity of 3221 MW generate the electricity and these stations have been connected to the national grid for power supply. Moreover, about 8 hydropower projects are under implementation and several more are under planning.

In this paper, hydropower resources in Myanmar, hydropower development strategy, existing hydropower stations, current status of hydropower and future plan are mainly described.

Keywords: hydropower resources, renewable energy, development strategy, *hydropower contribution, future plan*

I. INTRODUCTION

Myanmar, with a total land area of 676600 km^2 (264300 square miles) has currently population of 55 million. Its average growth rate is 1.75 % per annum. And, the increasing energy demand caused by raising population and improving standards of living can be satisfied by electricity facility. In Myanmar, there are many potential resources to produce electric power. Myanmar has mainly four rivers and three mountain ranges. The four rivers are the Ayeyawaddy, the Chindwin, the Sittong and the Thanlwin. The three mountain ranges are Rakhine Yoma, Bago Yoma and Shan Plateau. Four rivers are meandering between these mountain ranges and finally discharge into the Gulf of Mottama, dividing the whole country into four topographic regions. Therefore, according to the plentiful water resources and geographically condition, hydropower, which uses the energy of flowing water to produce electricity, becomes vital role in Myanmar.

The first hydropower station in Myanmar with the installed capacity of 460 kW was implemented on Yeni River in Mogoke, northern part of Myanmar and it was generated at 1898. The generation was used in mining process. In 1961, the hydropower station of Baluchaung No.2 with the installed capacity of 84 MW as 1st stage of project has been connected to national grid. In Myanmar, Ministry of Electricity and Energy brought most national energy and electricity activities under one umbrella and provided the framework for a comprehensive and balanced energy and electricity plan.

II. HYDROPOWER RESOURCES IN MYANMAR

Myanmar has abundant hydropower resources and the country's rivers can produce about 100,000 MW of electric power. But, 92 potential medium and large hydropower projects (between 10 MW and 50 MW are 32 numbers and more than 50 MW are 60 numbers) with the total potential installed capacity of about 46099 MW and 210 potential small hydropower projects (less than 10 MW) with the total potential installed capacity of about 231 MW have been identified. This hydropower potential, State and Region-wise including mini and micro hydropower are shown in Table I. And, hydropower potential in major River Basin including tributaries is shown in Table II.

TABLE I. HYDROPOWER POTENTIAL
(STATE AND REGION-WISE)

Sr. No	State / Region	Numbers of Potentials		Capacity (MW)
		>10MW ≤50 MW	>50 MW	
1	Kachin State	5	14	18,744.5
2	Kayah State	2	3	954.0
3	Kayin State	1	8	7,064.0
4	Sagaing Region	2	4	2,830.0
5	Taninthayi Region	5	1	711.0
6	Bago Region	4	4	538.0
7	Magway Region	2	3	359.0
8	Mandalay Region	3	6	1,555.0
9	Mon State	1	1	290.0
10	Rakhine State	3	3	764.5
11	Shan States			
	East	1	3	719.8
	South	3	5	7,569.5
	North	-	5	4,000.0
12	**>10 MW**	**32**	**60**	**46,099.30**
13	**<10MW**	**210**		**231.25**
	Total	**302**		**46,330.55**

TABLE II. HYDROPOWER POTENTIAL
(RIVER BASIN-WISE)

Sr. No	River Basin	Number of Hydropower Projects	Installed Capacity (MW)
1	Ayeyarwaddy	34	21821
2	Chindwin	8	3015
3	Sittaung	11	1128
4	Thanlwin	21	17,641
5	Mekong	4	720
6	Others	14	1776
	Total	**92**	**46101**

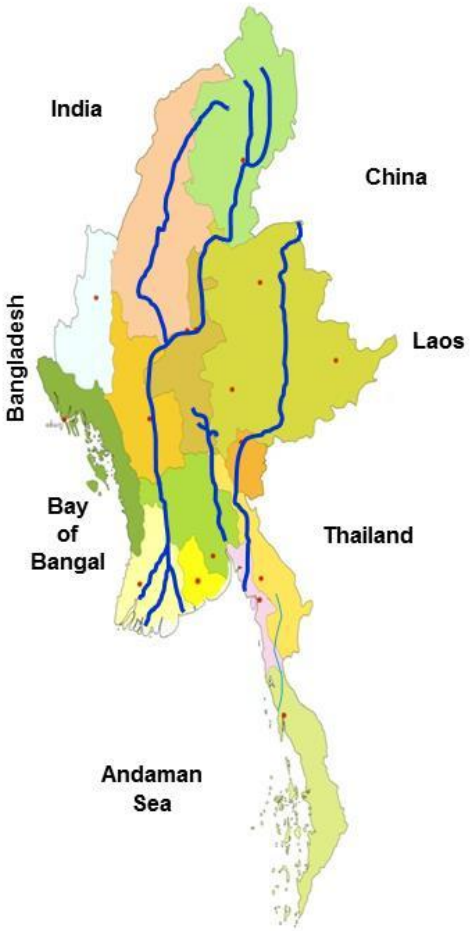


Figure (1) Myanmar Map

III. CURRENT HYDROPOWER CONDITION

(a) Existing Hydropower Stations

At present, total 27 numbers hydropower stations with the total installed capacity of 3221 MW have been connected to national grid. Among them, 22 numbers hydropower stations with the total installed capacity of 2110 MW have been implemented solely invested by Ministry, 2 numbers hydropower stations with the total installed capacity of 172 MW have been implemented by local entrepreneurs on BOT basis and the rest 3 hydropower stations with the total installed capacity of 939 MW have been implemented by foreign companies on JV/BOT basis.

TABLE III. EXISTING HYDROPOWER STATION

No	Stations	Installed Capacity (MW)	Annual Genera-tion (Gwh)	Remark
1	Baluchaung(1)	28	200	
2	Baluchaung(2)	168	1190	
3	Kinda	56	165	
4	Sedawgyi	25	134	
5	Zawgyi(1)	18	35	
6	Zawgyi(2)	12	30	
7	Zaungtu	20	76	
8	Thaphanseik	30	117.2	
9	Mone Chaung	75	330	
10	Paunglaung	280	911	
11	Yenwe	25	123	
12	Kabaung	30	120	
13	Keng Taung	54	377.6	
14	Yeywa	790	3550	
15	Shwekyin	75	262	
16	Kun Chaung	60	190	
17	Kyee Ohn Kyee Wa	74	370	**Sole Invest-ment**
18	Nancho	40	152	
19	Phyu Chaung	40	120	
20	Upper Paung laung	140	454	
21	Myogyi	30	135.7	
22	Myittha	40	170	
23	Thaukyegat(2)	120	604	
24	Baluchaung(3)	52	334	**BOT**
25	Shweli(1)	600	4022	
26	Dapein(1)	240	1065	**JV/BOT**
27	Chipwe Nge	99	433	
	Total Installed Capacity	**3221**		

(b) Existing Power System

In the existing power system consists of four components, namely, hydropower, natural gas, coal-fired power and diesel power generation. Currently, hydropower contribution accounts for the largest share in the power system. As a share of total installed capacity (5409 MW) on the grid, hydropower in power system currently accounts for 60% (3221 MW), natural gas accounts for 36% (1967 MW), diesel engine generation accounts for 2% (101 MW) and coal-fired power plant accounts for the remaining 2% (120 MW)and that generation mix is shown in Figure (2).

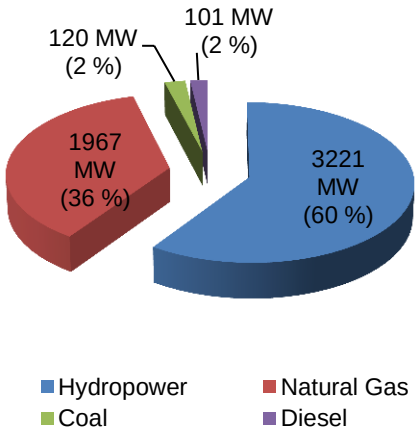


Figure (2) Generation Mix in Power System

(c) Hydropower Generation Condition

In the existing power system, daily average hydropower generation is estimated about 35100 MWh according to the design calculation and getting electricity percentage according to the actual hydropower generation for November 2017 is as follow:

Date	Peak Load (MW)	Average Load (MW)	Actual Energy Generation (MWh)	Getting electricity (%)
1-11-17	2050.20	1402.5	33691.32	95.99
2-11-17	1935.96	1313.02	31443.37	89.58
3-11-17	1665.23	1116.75	26811.24	76.39
4-11-17	1857.78	1276.76	30447.78	86.75
5-11-17	1995.97	1330.58	31661.23	90.20
6-11-17	2199.42	1489.17	35483.50	101.09
7-11-17	2238.47	1556.95	37011.48	105.45
8-11-17	2262.76	1599.50	38277.54	109.05
9-11-17	2277.55	1660.00	39660.54	112.99
10-11-17	2244.33	1699.68	40725.77	116.03
11-11-17	2202.24	1561.70	37608.05	107.15
12-11-17	1983.31	1402.00	33814.78	96.34
13-11-17	2085.44	1431.30	34466.46	98.19
14-11-17	2303.69	1609.41	38481.21	109.63
15-11-17	2270.66	1545.03	36941.22	105.25
16-11-17	2093.98	1387.60	33476.59	95.37

Date	Peak Load (MW)	Average Load (MW)	Actual Energy Generation (MWh)	Getting electricity (%)
17-11-17	1784.73	1256.77	30417.68	86 .66
18-11-17	1753.77	1130.17	26875.18	76.57
19-11-17	1737.85	1101.32	26453.87	75.37
20-11-17	1951.69	1318.63	30822.53	87.81
21-11-17	2075.60	1388.48	32614.44	92.92
22-11-17	1870.52	1316.06	30841.91	87.87
23-11-17	1921.80	1244.68	29736.21	84.72
24-11-17	1944.51	1335.97	31301.94	89.18
25-11-17	1603.10	872.62	19919.87	76.36
26-11-17	1678.82	1132.00	25996.07	74.06
27-11-17	1964.28	1314.84	31209.91	88.92
28-11-17	2237.86	1557.74	37258.83	106.15
29-11-17	2202.14	1517.17	36380.98	103.65
30-11-17	2083.82	1075.74	34041.23	96.98
	Total		**983872.73**	

Moreover, according to the comparison of monthly unit generation, it is found that hydropower generation in 2015 is 4% more than 2014 and hydropower generation in 2016 is 6% more than 2015 and that monthly unit generation of hydropower is described in Table IV.

TABLE IV. MONTHLY UNIT GENERATION OF HYDROPOWER

Mon-th	Y 2014 (MWh)	Y 2015 (MWh)	Y 2016 (MWh)	Prog-ress % (2014 & 2015)	Prog-ress % (2015 & 2016)
Jan	698357	663143	652603	-5%	-2%
Feb	633244	608869	705614	-4%	16%
Mar	746109	791716	896365	6%	13%
Apr	700147	816709	830231	17%	2%
May	704853	751024	878501	7%	17%
Jun	803153	675325	762710	5%	12%
Jul	814856	791374	846780	12%	7%
Aug	833310	858464	866719	7%	1%
Sep	763920	869986	871185	7%	0%
Oct	833310	858472	891600	3%	4%
Nov	763920	809144	818184	6%	1%
Dec	751189	679321	712693	-10%	5%
Tot	**8799564**	**9173547**	**9733185**	**4%**	**6%**

IV. POWER DEMAND AND POWER DEVELOPMENT STRATEGY

(a) Power Demand in Myanmar

In Myanmar, annual demand of electricity is increased 12 % according to the estimated demand and peak load condition of dry season. According to the NEP plan, electricity consumption of 2015 was 2527 MW and the estimated demand forecast up to 2030 is shown in figure(3).

Figure (3) Demand Forecast for 20 years period (2011-2030)

(b) Power Development Strategy

Due to increased demands to fulfill the electricity demand and reliable supplies of electric power is needed. Therefore, Ministry of Electricity and Energy laid down three strategies to implement the electric power projects and among them, hydropower projects are also implemented by three strategies, sole investment by Ministry, Investment by local entrepreneurs on BOT basis and Investment by foreign companies on JV/BOT basis.

V. HYDROPOWER DEVELOPMENT

(a) Background

In Myanmar, medium-scale hydropower development in stages beginning in 1960, with the installed capacity of 84 MW Baluchaung No.(2) hydropower plant that could supply 595 Gwh of electricity to Yangon and Mandalay. The second stage, starting in 1974, added

another 84 MW power plant with 596 Gwh annual average supplies. So, the total installed capacity of Baluchaung No. (2) hydropower plant became168 MW. Eight more hydropower plants, each with installed capacity ranging from 12 MW to 75 MW, were commissioned between 1974 and 2005. Development of larger capacity hydropower plants only started in 2005. During 2005-2011, another eight hydropower plants were built, with total installed capacity of 2094 MW, including two large scale hydropower plants with a combined capacity of 1390 MW (Shweli-1 commissioned in 2008 and Yeywa commissioned in 2010).

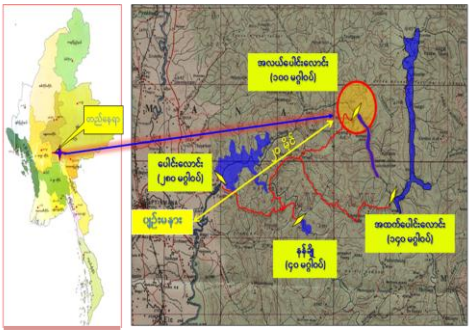
(b) Ongoing hydropower projects

At present, eight hydropower projects with total installed capacity of 1691.6 MW are under implementation. Among them, seven hydropower projects are implemented by sole investment by Ministry and the rest one is implemented by local entrepreneurs on BOT basis. General information of projects is described in Table V and location maps are shown in Figure (5).

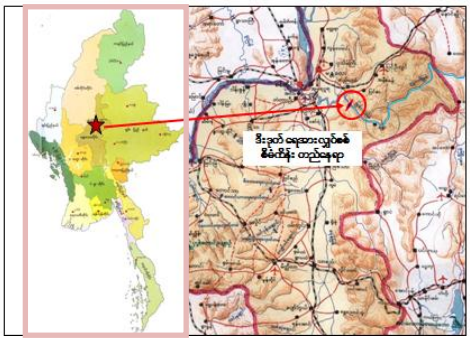
TABLE V. HYDROPOWER PROJECTS IN UNDER IMPLEMENTATION

Project Name	Location (State/ Region)	Capacity (MW)	Start year	Remark
Middle Paung-laung	Naypyitaw (Union Region)	100	2014	MOEE
Deedoke	Mandalay Region	66	2015	MOEE
Upper Nattrum	Kachin State	3.2	2014	MOEE
Thahtay	Rakhing State	111	2008	MOEE
Shweli-3	Shan State(N)	1050	2010	MOEE
Upper Yeywa	Shan State(N)	280	2010	MOEE
Upper Keng-tawn	Shan State(S)	51	2008	MOEE
Upper Balu-chaung	Shan State(S)	30.4	2010	BOT
Total		**1691.6**		

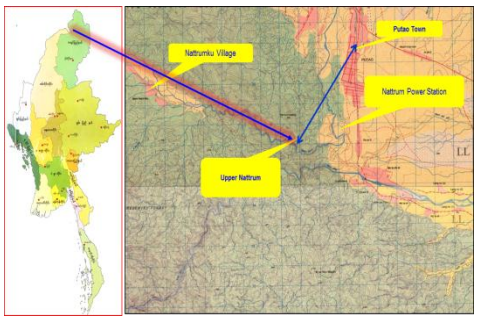
LOCATION MAP OF MIDDLE PAUNGLAUNG



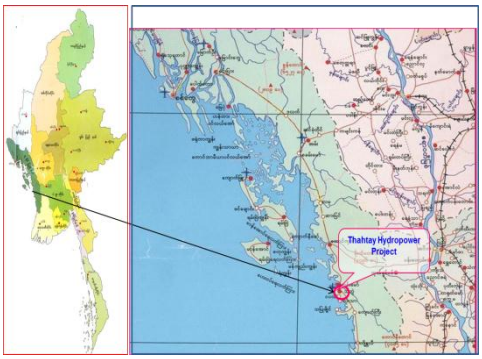
LOCATION MAP OF DEEDOKE



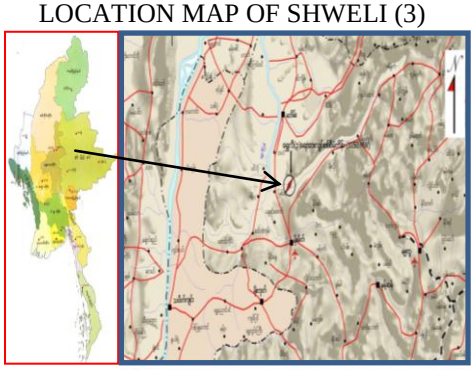
LOCATION MAP OF UPPER NATTRUM



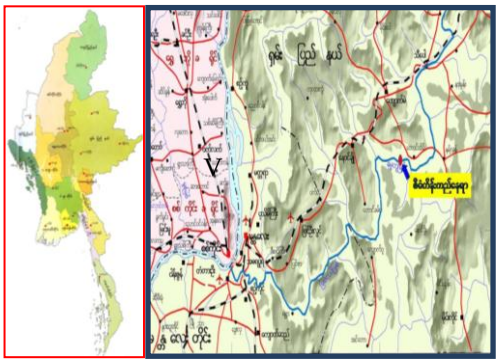
LOCATION MAP OF THAHTAY



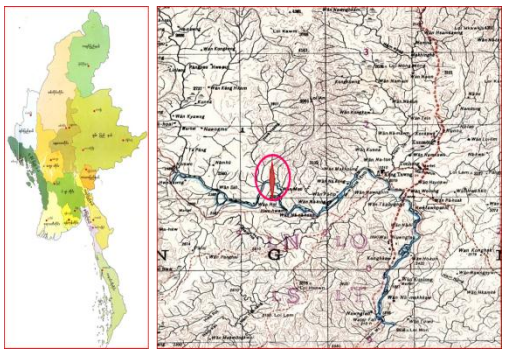
LOCATION MAP OF SHWELI (3)



LOCATION MAP OF UPPER YEYWA



LOCATION MAP OF UPPER KENGTAWN



LOCATION MAP OF UPPER BALUCHAUNG

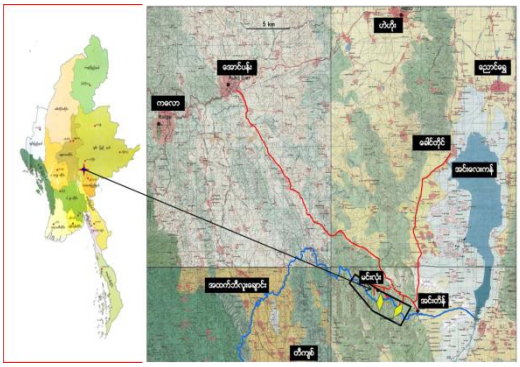


Figure (5) Location Maps of Hydropower Projects

(c) Present Status of Hydropower

Generally, hydropower can be defined into four categories under MOEE, identified hydropower potential, completed and generated hydro-power stations, ongoing hydropower projects and future plan projects. Among them, serial three categories have been already mentioned detail in above and the rest category is future plan projects. First of all, for clarification, these categories are briefly mentioned in general as follow:

(a)	Potential	92 no	46099 MW
(b)	Completed	27 no	3221 MW
(c)	On going	8 no	1691.6 MW
(d)	Future plan	57 no	41186.4 MW

However, according to present condition, there are 50 projects with total installed capacity of 41837.4 MW for future plan and that capacity of projects are estimated by investigation result.

47 hydropower projects, with the total installed capacity of 41721 MW by foreign investment on JV/BOT basic are future plan projects and among them, 28 hydropower projects in MOU stage with the total installed capacity of 12432 MW, 12 hydropower projects in MOA stage with the total installed capacity of 16030 MW and 7 hydropower projects in JVA stage with the total installed capacity of 13259 MW are respectively. Another 3 hydropower projects with the total installed capacity of 116.4 MW by local entrepreneurs on BOT basis are also future plan projects.

VI OBJECTIVES FOR ELECTRIC POWER SECTOR

At present, MOEE issued six objectives for electric power sector to meet the electricity demand and these are as follow:

1. In order to transmit the generated power, through National Grid System to Regions and States by implementing the Transmission Lines and Primary Substations, and by carrying out the Distribution Plans for

electricity supply to the Industries and Public.

2. To provide the technical know-how and policy support for using renewable energy such as bio-mass with co-operation and participation of the local people in rural areas, remotely located from the National Grid.
3. To meet the electricity demand for the inaccessible areas to National Grid, to be supplied by Mini Hydro and Diesel Generators.
4. In order to be reliable the quality of National Grid System for generation, transmission, distribution and consumption of electricity at the Standard Voltage Level with the least of power interruption and losses, to be carried out by our skilled staffs and by getting technical know-how from abroad.
5. In order to fulfill the electricity demand of Myanmar, to encourage the Power Generation not only Hydro and also Natural Gas and Coal, and to be widely and commercially operated by Wind and Solar Power Plants.
6. To generate more electricity from the renewable energy resources.

VII Policies for Electric Power Sector

Ministry not only issued the objectives for electric power sector but also laid down the following polices for power sector to get more and more improvement and to become efficient electricity utilities.

1. For sufficient electricity supply throughout the country, to expand the national power grid for effective utilization of generated power from the available energy resources such as hydro, wind, solar, thermal and other alternative ones.
2. To conduct the electricity generation and distribution in accordance with the advanced technologies and to uplift and enhance the private participation in regional distribution activities.
3. To conduct Environmental and Social Impact Assessments for power generation and transmission in order to minimize these impacts.
4. To restructure the power sector with cooperation, boards, private companies and regional organizations for more participation of local and foreign investments and formation of competitive power utilities.
5. To formulate the electricity acts and regulations with the assistances of the local and international experts in order to align with the open economic era.

VIII Rural Electrification Condition

The government of the Union of Myanmar continues to build, operate and manage the small hydropower plants to provide off-grid power. Previous time, 32 mini hydropower plants under MOEE with total generating capacity of 33.1 MW supply electricity to village and small industries not connected to the grid. At present, rural electrification and electrified household condition in Myanmar is as follow:

Budget year	Rural Electrification		Electricity Consumer (%)
	Total Villages	Electrified Villages	
2015-16	63860	30350	48%
2016-17	63860	31829	50%

Budget year	Electrified Household (Urban & Rural)		Electricity Consumer (%)
	Total Household (Million)	Electrified Household (Million)	
2015-16	10.877	3.7	34%
2016-17	10.877	4.06	37%

X. CONCLUSION

Electric power generation should be categorized in two parts. One is for base load and the other is for peak load. Generally, hydropower development has two schemes, run-of-river type and dam type. Run-of-river type hydropower station can produce continuous generation so this generation can be applied for base load. The generating sources for the base load should be environmentally friendly, economical and capable of mass generation for enormous power consumption. Meanwhile, the generation for the peak load should be a flexible one to provide flexible power in a sufficient amount to cope with the big load fluctuation. Moreover, as the environmental impact today is coming from generating source, hydropower, renewable source of energy becomes most favorite generating source. Geothermal, solar and wind power are the next.

And, renewable energy is a key element of solutions to sustainable development. At present, MOEE and collaborating agencies have been doing effort to implement the large scale hydropower projects and to establish modern standard for best-practice planning, implementation and operation of hydropower projects with the following ways:

(1) Technical Standards for Hydropower Standards
(2) Environmentally and Social Safeguard Standards for Hydropower Projects

Although the capital of hydropower project is more than gas turbine and steam turbine projects, long term electricity tariff is favorable for consumers. Therefore, hydropower project should be implemented in Myanmar and we can say that hydropower becomes vital role in power generation of Myanmar. So, if we can successfully implement the medium and large scale hydropower projects, future power sector of Myanmar will be best and brightest.

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