MYANMAR ENERGY

THE CASE FOR SMART LNG SOLUTIONS

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Myanmar Energy – The Case for Smart LNG Solutions by Alexander Dodge, Norwegian University of Science and Technology (NTNU). Faculty of Social and Educational Sciences, Department of Geography.

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Foreword

The Government of Myanmar has committed to providing universal access to reliable, affordable, sustainable and modern energy by 2030, in line with UN Sustainable Development Goal 7. Norway is a committed partner directly supporting these ambitious goals.

Access to energy is a key driver for economic development and poverty reduction. If Myanmar is to fully capitalize on its potential for growth, economic resilience, and sustainable development, a greater diversity of energy sources is needed. In line with the Paris accord, it is also important that the energy mix is CO_2-friendly.

Myanmar finds itself in the challenging position of having a shortfall between overall energy production and increasing domestic demand. Myanmar is thus considering its future energy mix. With a green energy transition in full bloom, the country is in a unique position: it can learn from the mistakes of others and choose to bring the country on a greener development path. It can leapfrog technologies, forgo coal, and make larger investments in green growth.

As a bridge to a fully renewable future, the shortfall in gas supplies can be offset by smart Liquefied Natural Gas (LNG) solutions. LNG is a commodity that is globally available and relatively clean. LNG contributes to reducing CO_2 emissions while at the same time improving local pollution, when compared to other sources of fossil-based energy production.

In recent decades, Norway's export of LNG from the Norwegian continental shelf has played an increasing role as a global source of energy. Norway's well-documented expertise in the LNG sector, bodes well for a closer energy partnership between Norway and Myanmar.

With this report we aim to contribute towards raising the awareness among all stakeholders as to the potential for flexible, quicker, cleaner and financially viable LNG solutions. Norway stands ready to collaborate with Myanmar.

Tone Tinnes
Ambassador of Norway to Myanmar

About the Report

This report is commissioned by the Royal Norwegian Embassy in Myanmar. It is written by Alexander Dodge at the Norwegian University of Science and Technology (NTNU).

The intention of the report is to highlight the role that Norwegian LNG-related technology can play in enabling sustainable energy development in Myanmar. Although this report is written primarily for Norwegian firms and counterparts in Myanmar, we believe that it will also be useful to everyone who is interested in Myanmar's energy development future.

Energy development is necessary to ensure sustainable economic and social growth in Myanmar. However, achieving sustainable energy development will depend on the ability for authorities, firms and local stakeholders to ensure proper public participation, manage recourses effectively, and take in consideration environment, local health, and wellbeing. The argument presented in this report, is that LNG, can help enable sustainable energy development. Research at the Department of Geography covers a broad range of fields across human and physical geography, including recourse management, sustainable restructuring, entrepreneurship and innovation, and urban development. The Department places a strong focus on sustainable restructuring in the energy sector, particularly within the Norwegian Oil and Gas Sector. Our current research projects focus on internationalization of Norwegian maritime and offshore firms into offshore wind markets and small-scale LNG market development in peripheral regions of Southeast Asia.

The development of the report has been supported by Innovation Norway in Myanmar. The writer of report would like to extend his gratitude to the organizations and stakeholders that provided their views on Myanmar's LNG, Natural Gas, and Energy Market development.

Alexander Dodge
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EXECUTIVE SUMMARY

On 8 November 2015 a historic step in Myanmar's transition to democracy occurred as the National League of Democracy (NLD), led by the Nobel Peace Prize winner and activist, Daw Aung San Suu Kyi, gained 80 percent of the electable parliament seats in a unprecedented election. On 30 March 2016, U Htin Kyaw was sworn in as the president of Myanmar with Aung San Suu leading by proxy. However, the former military government is nevertheless entitled by the constitution to 25% unelectable seats in the parliament and still holds considerable power in Myanmar. The NLD is under immense pressure to deliver on promises of economic and social development. The country still faces major challenges with the lowest GDP per capita in Southeast Asia and a low 38% electrification rate. Myanmar has one of the lowest energy uses per capita rates in the world at 263 KWh in 2015/2016[1]. Currently only 4 million out of 11 million households have access to electricity[2]. Additionally, Myanmar is facing electricity shortages with an expected unserved energy of over 20% from 2020.[3]

This report evaluates the energy sector and energy development plans in Myanmar. There are a number of challenges associated with large-scale hydro and coal-fired electricity generation and national grid expansion in Myanmar. Therefore, this report makes the case for LNG as an alternative solution to short-term energy needs and universal electrification. Norwegian firms have a long experience in the LNG industry and have pioneered a number of groundbreaking solutions in LNG supply, transport and regasification. However, this report acknowledges that project structuring within the current regulatory framework and financial capacity in Myanmar will be the key to success.

Myanmar may have a large hydropower potential, but some large hydropower plant plans would require residential relocation, deforestation and degradation of farm lands. Hydropower plants will therefore require proper environmental impact assessments and public participation processes, and are unlikely to be developed in the interim period. Developing coal-fired power generation in Myanmar would signify poor natural recourse management. If Myanmar follows through with coal-fired power plants, then most

1 (Oxford Business Group, 2017a)

2 (Zaw, 2017)

3 (Kean, 12 July 2017)

of these plants (if they are to be efficient) would need to rely on bituminous or sub-bituminous coal imports. Unless expensive pollution control measures are implemented, these plants are likely to wreak havoc on local environment and health as well as local agricultural and fishing industries. Natural gas is a less expensive and cleaner alternative to coal-fired power plants.

In addition coal-fired power generation and hydropower generation require extensive grid expansion, which is likely to be expensive and likely to exclude certain regions from electricity access. Distributed Generation focusing on solar and wind power has a large potential for providing electricity to off-grid villages. However often electricity supply from renewables is intermittent, and would rely on expensive diesel backups to provide stable supply, particularly for commercial and industrial needs. Given that Myanmar has an underdeveloped natural gas potential, and a largely unexplored frontier in offshore fields, then it is questioned if Myanmar should be locked-in into expensive and polluting coal-fired power generation. However, Myanmar struggles with attracting investment in offshore exploration and development, due to the lack of infrastructure, complex geology, fiscal terms, and demand.

A Floating Storage and Regasification Unit with a 500 mmscfd regasification capacity is seen as an interim solution to the electricity shortage and gas supply shortage, particularly in Yangon. However the draft in the Yangon river mouth is too shallow for a FSRU. According to a feasibility study, a FSRU would need to be located nearly 80km offshore from the Yangon River. In addition, the World Bank has commissioned a study that examined alternative locations in the Mon, Ayeyarwady, Rakhine and Tanintharyi regions, but these locations would require large capital investments in jetty and pipeline infrastructure. While an FSRU project is feasible, there are a number of challenges associated with developing the commercial framework, financing, and support infrastructure. These challenges are likely to delay the project.

In addition, there has been little discussion regarding the offtake of the 500 mmscfd regasification capacity from the FSRU. Peak gas demand in Yangon will be 370 mmscfd in 2024, and then dropping to 240 mmscfd as new gas fields are commissioned[4]. This is also based on

4 (Agha, Penglis, & Roland-Holst, 2016)

demand of the current gas transmission and generation infrastructure which is outdated and requires major upgrades. There has been some discussion of developing a 1,000 MW gas-fired power plant, but these plans remain fairly undeveloped. Current plans for gas-fired power plants have been delayed and projects have struggled to reach financial close.

Given the current situation, it is unclear if the FSRU could be completed on-time to solve the immediate gas and electricity supply gaps. There are still large institutional gaps after the merging of the Ministry of Electric Power and Ministry of Energy that has hampered effective decision-making. Little resolution regarding the commercial structure of the FSRU has been reached. Therefore it is expected that the FSRU project could be delayed. Nevertheless, the FSRU may still be viable for long-term gas demand growth and as an alternative to coal-dependent energy development.

However, if the upcoming electricity shortage is not solved, then Myanmar might need to rely on expensive diesel or HFO fueled power stations which are both expensive and polluting. This report therefore suggests further inquiry and research into short term, medium-sized LNG solutions that are less capital intensive and more suitable to the given fiscal and regulatory framework. 250 MW LNG-fueled power barges could be located further up the Yangon River and connect to the existing transmission grid. By connecting to existing infrastructure, such a project would implicate significant cost-savings on gas and electricity transmission infrastructure. Such a plant could both generate electricity and supply 600,000 tons of LNG to the current pipeline transmission grid. The project structure could be based on a similar PPA structure as the 250 MW Myingyan tender, which is considered the future framework for contracts. Given current LNG prices, such a project could deliver gas at a similar price as domestic gas fields. The main challenge will be the issue of guarantees, but the project should be manageable within the current financial situation of Myanmar. Similar projects could be implemented in other locations in Myanmar and also serve as hubs for further small-scale LNG distribution via trucks or barges to more remote locations. Norwegian firms have a number of solutions and experience with LNG distribution and infrastructure, and can help support Myanmar's energy development plans.

The central argument presented in this paper is that LNG can enable an alternative path to energy development. Energy development should be scaled and modularized according to actual energy needs, be they residential, commercial or industrial. LNG could enable renewable energy development through grid back-ups and would be far less expensive than HFO and diesel generators. LNG could also enable infrastructure development for domestic gas supply and the natural gas sector such as electricity generation, fertilizer and petrochemical industries. Doing so could help attract investment in domestic natural gas exploration, development and production activities. This stands in contrast with other proposed development trajectories that assume energy growth based on GDP growth forecasts, with little consideration to how economic productivity will be established.

1. The Energy Sector in Myanmar

With an electrification rate of only 36%, energy development will be essential for economic and social growth in Myanmar. However, currently energy development plans involve large hydropower and coal-fired power plant projects, which have been controversial and have often been delayed or cancelled. Myanmar is already facing energy supply shortages and it is unlikely that large energy projects will solve its immediate needs.

	Installed Capacity			Total	
Type of Power Plant	State	JV	IPP	MW	%
Hydropower	2,070	838	172	3,181	61%
Gas Turbine and Combined Cycle	993		351	1,344	26%
Gas Engine			570	570	11%

Table 1: Existing Installed Capacity of Power Plants (On Grid). Source: MOEE

CURRENT STATUS

Myanmar currently has a total of 5,215 MW of installed capacity on the national grid. Currently hydropower accounts for 61% of installed capacity in Myanmar.[5] Unlike Norway, where hydroelectric supply is relatively stable, supply is intermittent in Myanmar, as dry season power supply from hydroelectric plants decreases 30% compared to the wet season. April is the end of the dry season and tends to be the driest month. Electricity outages tend to be common in the dry season.

Gas Turbines and gas engines account for 26% of the energy mix. There are currently ten government owned and nine independently owned gas-fired power plants operating in Myanmar with a combined total installed capacity of 1,714 MW. Most of the gas-fired power plants provide electricity to Yangon. However, the government power plants owned by the Ministry of Electricity and Energy (MOEE) are all built before 1996 and poorly maintained, with the exception of the Ywama plant and the Thaton power plant which was upgraded with a new combined cycle gas turbine (CCGT). The FEED (front end engineering and design) for the Thaton CCGT project was notably undertaken by the Norwegian consulting firm Norconsult and financed by the Norwegian government[6]. However, in addition to power plants, the transmission grid is highly inefficient, with a 23% power loss on transmission and distribution[7]. Myanmar has few high-voltage electric lines, and even if new generation capacity was built, transporting it would require major upgrades to the grid and substations.

5 (Zaw, 2017)

6 Stian Carl Erichsen. Thaton Case Study. Norconsult. 10 February 2016

7 (Myint, February 2016)

Another major challenge for electrification is that the population is spread throughout the country. Rural citizens, 70% of the population, report paying between 10 to 20 times what government subsidized grid power costs, and need to rely on alternative sources such as diesel-powered mini-grids. Diesel fuel per liter varies between MMK 4,400-4,900 and the cost of electricity per kWh for a diesel-powered generator is MMK 1,111 (WB National Electrification Plan). Most of the rural population, however, has no access to electricity and relies on candles for lighting and biomass for cooking. The use of biomass in cooking has known consequences for local health[8]. Access to electricity is considered vital for bringing the population out of poverty.

Based on a USTDA study from Delphos ***unserved energy (outages) of over 20%*** are likely from 2020 through 2022, unless decisions are made to proceed with power projects in the near future.[9] This compares to the three or four percent now. Power shortages are likely to impede the rate of economic growth in Myanmar. The situation for Yangon is especially urgent, as total energy usage in the downtown area of the city rose 20% from 2015-2016, and is estimated to be 1,250 MW.[10]

Insufficient gas supply is currently hindering the utilization of power-generation capacity near Yangon. Energy shortages can hinder economic growth, as a number of industries require stable energy supply.

ENERGY MASTER PLANS AND FORECASTS

Electricity Demand in Myanmar increases 10-15% annually[11]. Myanmar currently has three Master Plans for Power Development developed during the previous regime. None of which have been officially approved by the new NLD government. These plans include the National Electrification plan, which is developed by the World Bank and the UN, and the Myanmar Energy Master Plan which was introduced in 2016 by Myanmar's National Energy Management Committee and sponsored by the ADB, and report developed by JICA in 2014. The National Electrification Plan aims for full electrification by 2030, with 50% access by 2020 and 75% by 2025. An estimated 20 GW of generation capacity would need to be added.

8 (World Health Organization, 2016)

9 (Kean, 12 July 2017)

10 (Oxford Business Group, 2017a)

11 (U Moe Thu Aung, 2017)

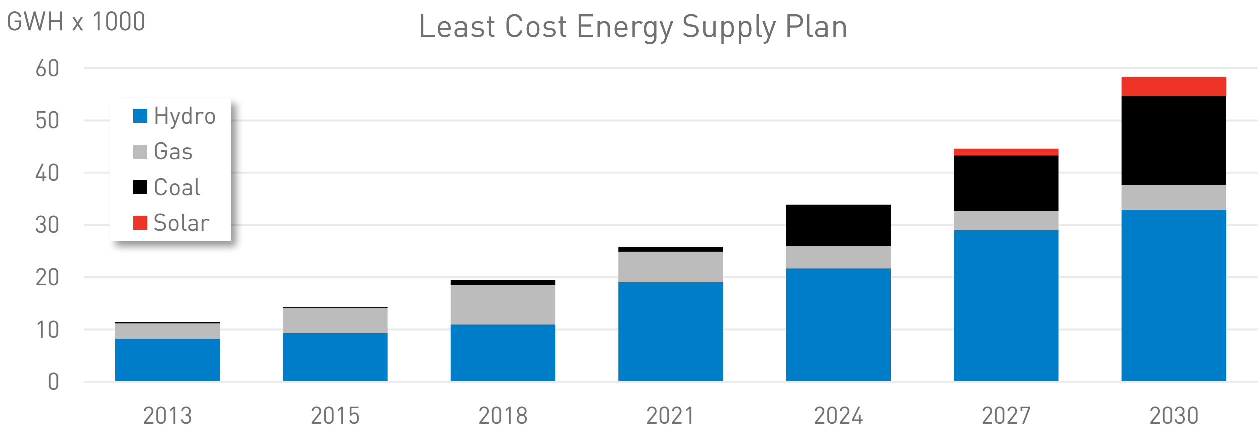

Figure 1: Graph showing Least Cost Energy Supply Plan for Myanmar. Source: NEMC

The National Energy Management Committee and JICA Plan includes large increases in coal-fired generation and hydropower. However, the NLD is negative towards hydropower megaprojects that cause major environmental harm and will instead focus on repairing and maintain existing dams and identifying projects with lower environmental and social impact. In addition, coal-fired power plants face considerable resistance in Myanmar, and are politically risky for the new government to develop. It is still unclear if the government will release a new master plan for energy development. The government nevertheless has promised to develop 80% electricity access in Myanmar by 2030.

The main focus of the National Energy Master Plans are centered on installing large-scale power generation capacity and extending the national energy grid. Myanmar's financial capacity is likely to be insufficient to guarantee the development of large-scale infrastructure development. Significant upfront costs will be required for grid extension, and under the current system these costs are born by villages and individual households. The following sections outline the challenges of developing large-scale hydropower and coal-fired electricity generation, in addition to national grid roll-out.

Hydropower

Myanmar has significant water recourses, with an estimated 100 GW of theoretical hydropower potential. The ADB energy master plans call for a significant increase in hydropower generation. The least cost power plan calls for an increase of nearly 230% from 2015 to 2024 in hydropower generation. The "least cost" plan assumed 2,000 MW of Hydropower developed from 2016 to 2020. This plan has been lambasted by commentators[12], who argue that this was unrealistic within the timeframe given previous experience with hydropower projects in Myanmar. A number of hydropower projects in Myanmar have been considered controversial and have been delayed or cancelled. The previous ruling regime approved 49 hydropower projects, but these projects are being scrutinized under the new regime[13]. Of these 49 projects, only 12 dams have been commissioned, the largest being the 1,050 MW, Shweli 3 dam. Hydropower projects take considerable time to develop: over three years to construct, and two to five years for development and financing. Such projects can take an even longer time due to delays with environmental impact assessments and protests.

While Myanmar has a large potential for hydropower development, projects are scrutinized as they can require displacing local residents and flooding of agricultural lands. The NLD Election Manifesto recognized the environmental harm of hydropower and has sought to increase electricity generation through repairing and improving existing facilities.[14] Sources say that currently the NLD is positive to hydropower projects with proper procedures and low environmental and social impact.

Several projects have faced considerable opposition as they often involve energy exports to neighboring countries. A 7,000 MW Megaproject, the Myistone Dam, has been in development for nearly a decade. The project was heavily criticized as 90% of the electricity was to be exported to China. After public opposition in 2011, President U Thein Sein suspended the construction of the USD 3.6 billion dam.[15] After the NLD was elected, a report committee was established to evaluate the project, and in 2016, the Myanmar Times reported that the project would be canceled. However, this is uncertain as there are several challenges to cancellation, including the repayment of USD 800 Million in investments to

12 (Kean, 12 July 2017)

13 (Oxford Business Group, 2017c)

14 (National League for Democracy, 2015)

15 (Rabin & Madden, 1 October 2015)

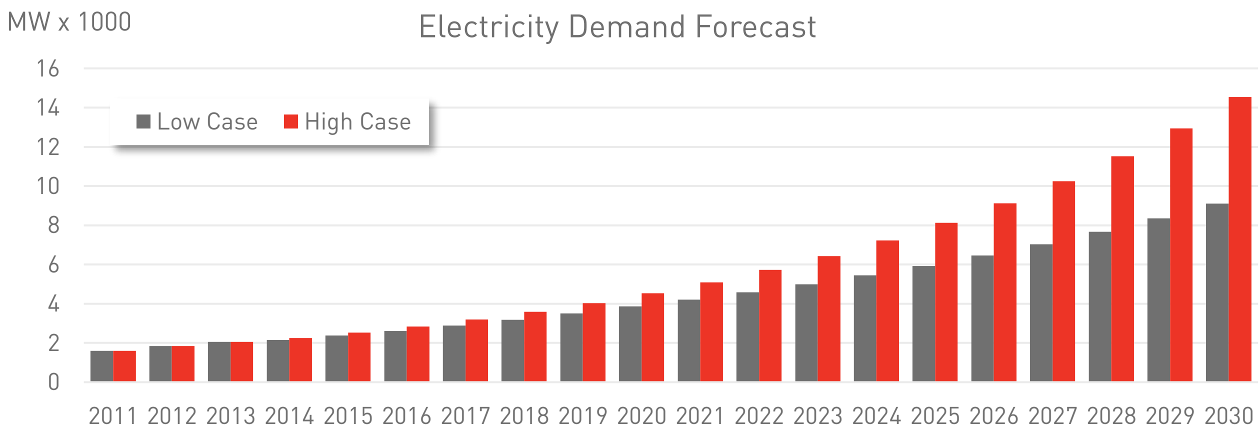

Figure 2: Graph showing electricity demand forecast for Myanmar. Source: MOEE

the developer. Other projects including the Tamanthi and Shewsaye dams on the Chinwon River were also cancelled due to opposition. The 111 MW Thahtay project which started in 2004 remains less than 50% complete and the cost has been much higher than expected. However, the reason for suspensions and delays of Hydropower projects are not only due to opposition. Other reasons are[16]:

- A number of projects face long construction periods or expensive project costs, particularly in locations with no available infrastructure such as roads, lodging, schools, transmission grids, etc.
- Many of the projects were signed under the previous government. A number of the agreements have been cancelled by the new civilian government
- Myanmar heavily subsidizes electricity, and national utilities face a situation where the more non-industrial power they sell, the larger the losses. Thus discouraging private investors or investors who require government guarantees, which the government is unwilling to provide.
- The former projects negotiated by the previous government had poor contractual terms for Myanmar, with a brunt of the

16 (Hennig, 2016)

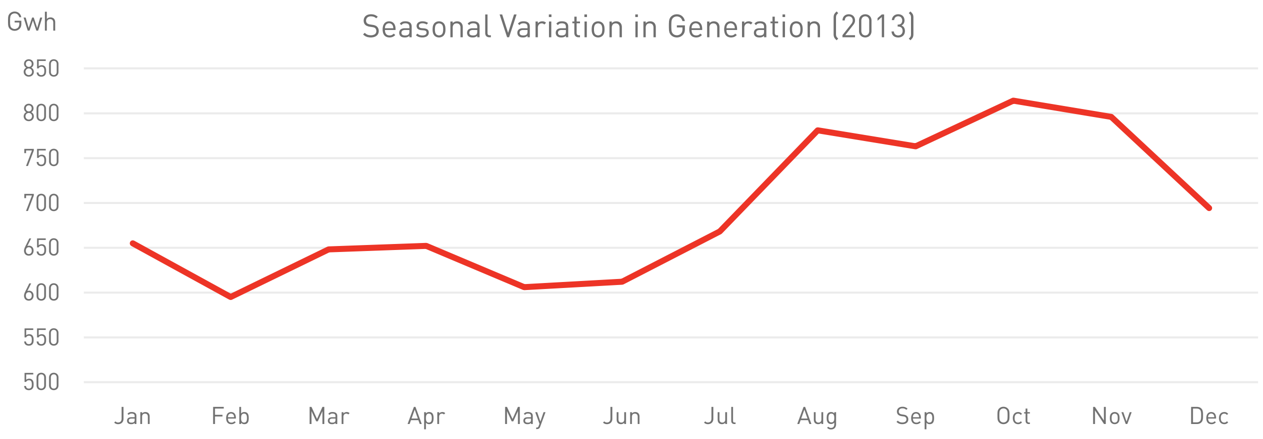

Figure 3: Hydropower capacity is reduced 30% in the dry season Source: NEMC

power allocated for export to China or Thailand.

- The environmental impacts of hydropower projects were not properly assessed under the previous regime. Affected communities are expecting, under the new regime, to participate in planning. The carbon footprint of projects needs to be assessed if they lead to deforestation.

Large-scale Hydropower projects are therefore likely to be renegotiated and a number of these projects probably won't be commissioned until after 2020. Therefore hydropower will be challenging to develop in the near-future. While Hydropower is likely to pay a role in developing energy access in Myanmar, it will be essential to ensure adequate public participation in projects and consultation with community organizations, particularly in national areas. While Hydropower generation is cost effective, projects will require significant financial investments. Hydropower is geographically limited and often located far from demand centers, and therefore requires extensive grid expansion. As Hydropower generation is seasonally intermittent and reduced significantly in the dry season, other energy recourses will need to be developed and transmitted through the grid. As will be explained in a later section, grid expansion is likely to be expensive and unlikely to serve the energy needs of the larger population in a short-term scenario.

Coal-Fired Power Generation

The Least Cost Energy Supply Plan in the ADB master plan calls for increasing electricity generation from coal nearly 230% from 2015 to 2024, and 350% from 2015 to 2030. This represents a target of 7,940 MW of coal-power added. However such plans are largely unrealistic. Today coal-fired power generation in Myanmar is relatively small, with only a 120 MW plant in Tigyit built by Chinese developers in 2001 and an 8 MW plant in the Taninthary Region. The Tigyit coal plant has faced calls to be shut down by local groups in 2016. The plant is powered by the Tigyit coal mine, which only produces low quality lignite fuel, which is highly polluting and inefficient. Coal-Fired power generation in Myanmar is highly controversial and any proposed plans are likely to face protest from residents and activists. No other plans for coal-plants have materialized. Similar to hydropower, coal-fired power generation has high capital costs and is likely to take a number of years to develop, finance and construct.

In 2010, 11 Coal-Fired Power Plant Memorandum of Understanding (MoU) were signed, but none of this capacity has been developed[17]. Projects are often controversial and have been delayed and cancelled. The new NLD government has been noticeably vague on if it will carry through with developing coal-fired power generation capacity. The World Bank has also stated that it will not provide financial support to coal-fired power plants[18]. Some of the coal-fired power plants that have been delayed or cancelled include:

- 2,640 MW power plant in Myiek with a MoU signed in October 2013 has not had any developments since 2014
- A 1,320 MW powerplant in Kyaukphyu has not had any developments since May 2015 and was protested by local residents
- A 279 MW coal plant in the Htantabin Township, Yangon was cancelled by the MOEP in July 2015
- A 1,280 MW supercritical plant in the Ye Township has been subquently delayed. In May 2015, 5,000 people from villages across the Ye Township gathered in Inn Din village to protest the power plant.
- A 4,000 MW powerplant in Dawei was cancelled in 2012 following opposition by the

17 (Shin, 1 September 2015)

18 (Nyien, 14 March 2016)

Karen National Union and an awareness campaign by local residents.

Myanmar's coal reserves contain low quality, lignite coal and is unlikely to be sufficient for power generation in the country. Experience from lignite power coal-plants, such as the Mae Moh power plant in Thailand, show that these plants often have high sulfur and particulate emissions pollution. This is particularly damaging for the environment and local health. Therefore, if the country is to build coal-fired power plants it will likely need to rely on importing higher-quality bituminous coal. Such plans would likely signify poor recourse management, as Myanmar has a potential for new natural gas finds in the Bay of Bengal, albeit underdeveloped. Not only would natural gas be significantly less polluting, but it is also cost-competitive against coal-power. A comparison of the environmental and commercial benefits of natural gas power generation can be found in the appendix.

National Grid Expansion

Large-scale energy projects tend to be located farther away from demand centers, particularly hydropower projects which are notably geographically limited and intermittent. As such projects are located far from demand centers, they then often rely on high-voltage transmission lines, which is likely to result in transmission losses depending on the quality of the grid. In September 2015, the World Bank approved a USD 400 million loan to support the National Electrification Plan. The first phase of which seeks to extend electricity access to over 1 million households by 2021, 60% of which will connect to the national grid. In order to reach full electrification by 2030, the World Bank estimates that over 517,000 connections need to made every year.

Large scale energy projects tend to prioritize development in central demand centers and thereafter geographical locations most suited to connect to the energy grid. Small rural households far from the grid can therefore end up with no access to electricity for a long period of time. Areas that are in mountainous regions, such as the Chin, Kachin, Kayah and Shan states, will provide significant topographical challenges to grid expansion and are likely to be under prioritized in grid connection. A summary of the costs of grid extension costs according to the NEMC master plan is found in the table below.

Priority Investment for 2017-2025	IPP	Transmission		S/S	Total
	MW	km	USD	USD	USD
Connection of Power Plants	5,064	1,022	554	339	893
Connection of new Areas NEM Project		975	365	187	552
500kV Backbone System (MOEP)		1,795	1,077	149	1,226
Strengthening of Network		408	143	78	221
Total Transmission Investments		4,200	2,140	753	2,892

Table 2: Summary of Transmission Projects Identified by Fichtner/MOEP (USD billion). Source: NEMC

Expanding the national grid is favored in Myanmar as it provides around-the-clock energy supply and can support higher voltages for supplying firms and industries. However, grid extension requires substantial investments and the currently regulatory framework is challenging and must be developed. The NEP relies on a self-reliant approach, where the grid is built into the township level. Therefore the township must organize and collectively finance the connection, which can cost a village between USD 30,000 to 50,000 or about USD 250 per household, nearly double the average monthly income. Little financial support is available, and the emphasis is put on raising funds from collective savings, which puts poorest villages at a disadvantage. Certain households might not be able to afford to contribute to the collective savings, and can then be excluded[19].

Significantly expanding electricity generation capacity and extending the national grid to rural populations is favored in Myanmar. Large power projects such as coal and hydropower are often tempting because of the perception that larger projects develop economies of scale. The idea is simply that unit costs are lower due to increasing size and use of facilities. An extended grid with sufficient energy generation capacity could be easier to scale, thus reducing generation cost per unit and the ability to integrate and distribute a range of energy sources. However achieving universal access by 2030 would require nearly 7.2 million households to be brought into the grid over 16 years.[20] According to International Growth Center, large-scale grid expansion is

19 (Dobermann, 2016)

20 (Rabin & Madden, 1 October 2015)

unlikely to be sufficient in itself for Myanmar's long-term development goals.

CHALLENGES OF LARGE ENERGY INFRASTRUCTURE PROJECTS AND GRID ROLL-OUT

Large energy infrastructure projects are unlikely to solve Myanmar's impending energy shortages and are insufficient by themselves to achieve universal electrification. There are different definitions of what a large energy infrastructure project is in terms of size. An IEA assessment, for example, defines large-scale hydropower project as over 300 MW. However, there is also a significant difference also between a large 300 MW power plant and a 1,000 MW mega power plant. Nevertheless, given the experience in Myanmar with large coal and hydropower plant plans, such projects are likely to be delayed and experience cost over-runs. Due to the long development, financing and construction times, such projects are simply not feasible for solving the short-term energy needs. With no legal structure available for such projects in place, then the risk of delay is even greater. Research on energy megaprojects[21] have shown that large energy projects often fail to succeed due to several reasons. Often the size of such projects mean the more stakeholders are involved, this creates the inability to allocate project value fairly among participants, internal conflict is avoided, costs and benefits are misrepresented in order to gain strategic advantage. Mega hydro and coal power plants along Myanmar borders are case and point, as developers tend to seek to export most of the energy generation to neighboring countries to improve bankability. Thus creating conflict regarding the fair allocation of energy recourses.

There is also a question of project externalities. Large projects tend to externalize the costs and consolidate the benefits, and questions regarding the costs of environmental degradation or pollution often are not taken in account. Costs can be strategically misrepresented. Large projects often lie in nationality areas, and increase tensions due to environmental impacts. Environmental impact assessments, according to commentators[22], have become more complicated in Myanmar, due to more participation by different actors, and can lead to delays. Land-rights and relocations also raise serious concerns. When disputes arise, there is a question of how they will become settled and what means will be used. The NLD was vastly

21 (Sovacool & Cooper, 2013)

22 Interview February 2017

opposed to land-grabs and forced relocations that occurred in the pre-2011 government. Ensuring public participation in project will be a key governance issue.

Myanmar has a long history of civil conflict between the Myanmar military and ethnic organizations, such as the Karen Nationality Union. The Karen conflict is the largest internal war in the world, having been waged since 31 January 1949, although a tentative ceasefire was signed in 2012. A number of conflict areas in Myanmar's ethnic territories exist along the Myanmar border with Thailand and China. Planned Hydropower plants and gas-pipelines for energy exports, often backed by China and Thailand, have exacerbated tensions and conflicts in ethnic areas. Such projects have historically provided little or no benefits for these areas. Forced Relocations, violent oppression of protests and insecurity for dam workers have been hugely problematic for large hydropower and gas pipeline projects. [23] The costs of conflict cannot be externalized and any project will need to ensure adequate public participation, even if this may result in delays or cancellations.

Even if these large-scale energy generation projects are developed, there is still a question of achieving significant support infrastructure systems in order to achieve low cost electrification, which further increases the complexity of such projects and their viability. Chicken and egg problems arise, in which energy generation projects struggle to achieve investment due to lack supporting grid infrastructure and vice versa. In order to address the challenges of national electrification, Myanmar must develop its skilled human recourse potential and improve its institutional capacity and management expertise[24]. Large-scale projects also suffer from reliability problems, particularly coal-fired power plants. An average 600 MW coal-plant for example, is out of service 10 to 15% of the time[25]

The point here is not to discredit national grid expansion or its merits, but to argue against bias and over-confidence of large-scale energy projects and grid roll-out. Poor energy governance can lead to serious challenges in energy development, and emergency situations where the highest-cost option is chosen. Experience from countries such as Bangladesh

23 (Simpson, 2016)

24(Rabin & Madden, 1 October 2015)

25 (Sovacool & Cooper, 2013)

(presented in a later section) show that poor-energy governance can lead to energy shortage crisis and in the long-run lead to poor energy security and high costs.

Given that energy shortages in Myanmar are impendent, it will be essential to focus on feasible, short-term solutions to solve immediate energy demand. In addition the technology and experience with alternative solutions, such as distributed energy generation, are becoming increasingly scalable and affordable. Proper recourse management and energy efficiency can also go a long way in ensuring stable electricity supply.

DISTRIBUTED ENERGY GENERATION

Distributed generation (DG) refers to on-site electricity generation, in small-increments, that are close to end-users. Researchers[26] have noted that better technological solutions for DG are becoming increasingly available and are eminently scalable. Technologies are often not distributed only by traditional power providers, by but home-owners, commercial enterprises and industrial firms. Distributed generation can also be placed anywhere, near high-voltage line, low-voltage lines, or off-grid. Excess heat from generation can also be recycled for use for industrial processes that require heat through combined heat and power systems, such as petrochemical, paper and pulping industries. Distributed Generation refers to a range of technologies from wind power, to Solar PV, Geothermal, Biomass Generators, Small-Hydropower dams, and Small-Scale LNG solutions.

Given that Myanmar has high solar radiation rates and a potential annual output of solar at 51,973 Twh and 4,032 Twh for wind power, in addition to a large micro-hydropower potential, distributed generation in many cases could be feasible. Smaller decentralized units utilizing different technologies such as solar, wind and small-scale LNG would be quicker to implement than large-scale power plants. The telecommunications industry in particular has an interest in promoting distributed energy generation. The GSMA (Groupe Speciale Mobile Association) forecasts that by 2017 approximately 9,900 telecommunications sites in Myanmar could be viable for renewable generation. Energy services companies could partner with tower companies and mobiles network operators for deployment and management of energy systems

26 (Sovacool & Drupady, 2016)

and towers throughout the country. Norfund and Yoma Strategic Holdings Ltd. are currently cooperating on a project to establish distributed generation micropower plants and minigrids for off-grid rural communities and telecommunications towers in Myanmar.[27]

Distributed Generation, however, is not without its challenges. Distributed generation may not always have environmental benefits as poorly built gasifiers can lead to local pollution. A number of current mini-grids in Myanmar run on diesel generators, which are notably expensive, costs are USD 2 to 5/month for a couple hours of electricity during the evenings.[28] One informant[29] noted that some fish processing industries with a 20 MW diesel generator pay up to USD 0.46/Kwh. Due to the intermittency of some technologies, such as solar, diesel back-ups might be needed. In addition, distributed generation may not serve industrial or commercial needs that require larger amounts of stable electricity. In a later section I will explain how LNG solutions can be modular, scalable and flexible in terms of meeting commercial needs and support plans for distributed generation.

The National Electrification Plan includes a pre-electrification plan to provide off-grid electricity to 3-4% of the villages in the last phases of the grid roll-out. This plan includes solar home systems (75-175 Kwh/year) for small villages and mini-grids (200-250 Kwh/year) for larger-grids. However this paper focuses on distributed generation ranging from 0.5 MW to 300 MW. Regional governments are not allowed to implement projects larger than 30 MW[30]. However a new update in the 1984 electricity law may promote state-level governments to take a lead in promoting off-grid power infrastructure projects. Due to the challenges of large-scale power development, medium to small-scale generating assets will likely play a critical role in solving short-term energy crisis and achieving universal electrification.

27 (YOMA Strategic Holdings ltd., 2 May 2017)

28 (Rabin & Madden, 1 October 2015)

29 Interview February 2017

30 (Oxford Business Group, 2017b)

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2. Natural Gas in Myanmar

The first offshore natural gas field in Myanmar was commissioned in 1999. Most natural gas production, however, is exported to Thailand and China and domestic allocations are insufficient to meet gas demand in Myanmar. Myanmar has struggled to attract investment in its upstream natural gas sector due to the lack of infrastructure and poor fiscal frameworks. Deepwater areas in Myanmar remain largely unexplored and could prove to hold large natural gas deposits.

Gas Production in Myanmar	Yadana	Zawtika	Yetagun	Shwe
Production Start	1999	2014	2000	2014
Production End	2027	2029	2024	-
Export (mmscfd)	565	400	400	400
Domestic (mmscfd)	225	100	-	100
Domestic 2025/26	22-31%	23-47%	-	20%
Expected Production 2025/26 (tcf)	100	77	-	182

Table 3: Summary of Summary of gas production in Myanmar. Source: METI

RESERVES AND PRODUCTION

Myanmar has an estimated proven gas reserves on 16.6 tcf (MOE 2013). Woodmac estimates that the remaining commercial reserves are at 240.7 bcm with a potential for another 237.8.[31] Myanmar's upstream gas production peaked at 53.8 MMcm/d in 2015 and the country is expected to pump 52.4 MMcm/d during 2017.

Currently there are four operating fields: Yadana, Zawitika, Yetagun and Shwe. The Aung Sinkha Field (M-3) block owned by PTTEP has an expected production start in 2025, with 140 mmscfd net gas pay. The A-6 and AD-7 Block, owned by Woodside, is set to be appraised and could have an expected production start after 2025. The Badamyar field (M-5), a satellite to the Yadana Field, has reserves of 170 bcf and production levels could be around 45 mmscfd starting in 2029/30[32].

GAS SUPPLY AND DEMAND

While Myanmar is rich on natural gas deposits, domestic natural gas supply is limited. The pre-2011 government, in order to raise finance, entered into contracts to export natural gas to Thailand and China (ADB). Today 80% of the natural gas produced is locked under long-term contracts to China and Thailand. Therefore, the state-owned Myanma Oil and Gas Enterprise (MOGE), which is responsible for exploration and production of natural gas, can only allocate 320 MMscfd[33] for domestic gas consumption. The

31 (Evans, 28 March 2017)

32 (Ministry of Economy, 2016)

33 U Win Myint, 2016

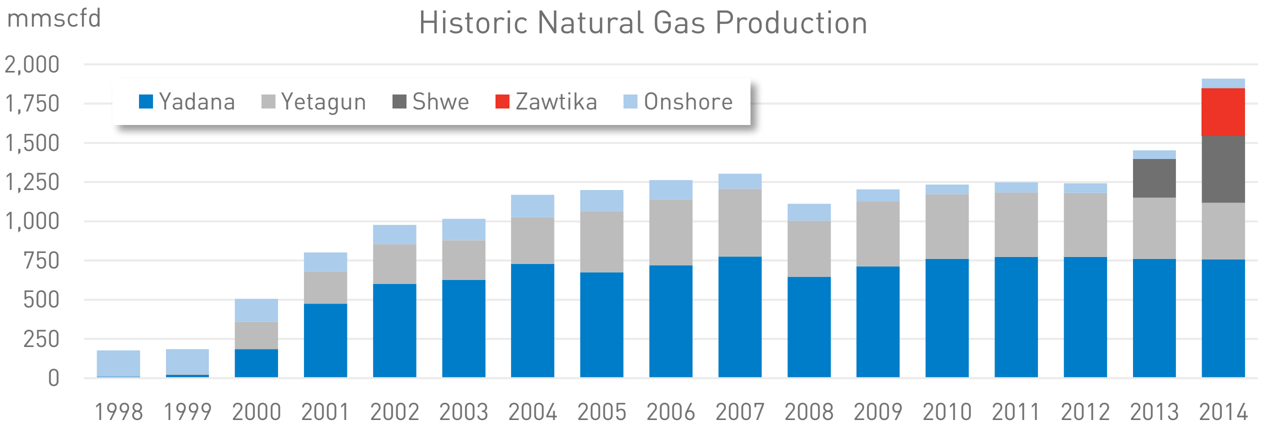

Figure 4: Graph showing historical natural gas production in Myanmar. Source: NEMC

demand for gas in Myanmar was around 300 MMscfd in 2015[34].

The power sector currently is the main user of domestic gas supply. There are currently 10 government owned and 9 Independently owned Gas-Fired Power Plants operating in Myanmar with a combined installed capacity of 1,714 MW. Natural Gas demand, which is currently 9.9 MMcm/d could hit 14.2 MMcm/d by 2020 as the economy is forecasted to continue expanding. The countries demand for gas could be 11.3-22.7 MMcm/d by 2026, but Woodmac's base estimate is 15.9 MMcm/d (Intefax). According to a report by METI, domestic gas supply is not sufficient to cover the demand of power stations, and shortfall of 650 mmscfd could be expected in 2025 and more than 1,100 mmscfd in 2030. A World Bank report, however provides a lower estimate that from 2018-2019 there could be a gap of gas demand at 50 mmscfd and increasing to 420 mmscfd in 2024-2025. These increases in demand account for the planned construction of new gas-fired power plants, some of which have not yet reached financial close, as will be explained in a later section.

34 (Agha et al., 2016)

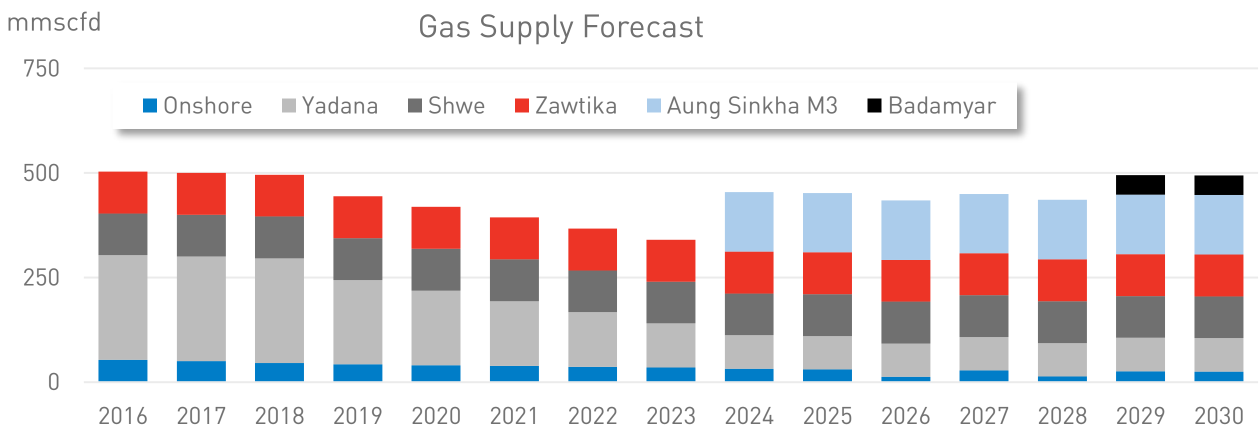

Figure 5: Graph showing gas supply forecast for Myanmar. Source: E.gen

NATURAL GAS COSTS

A report by E.Gen consultants commissioned by the World Bank makes an initial assessment of the economic costs of natural gas for Myanmar[35]. According to the report the 2016/17 contract price is USD 7.7/mmbtu for the Shwe Field, USD 6.3/MMbtu for Yadana, and USD 6.3/mmbtu for Zawtika. Field prices are USD 5/mmbtu for Shwe, USD 3.9/mmbtu for Yadana, USD 3.8/mmbtu for Zawtika. By 2020 the contract prices are expected to increase USD 8.60, 8.40 and 8.40/mmbtu respectively.

The calculated Long Run Average Cost Estimation (LRAC) ranges between USD 3.47/mmbtu and USD 8.11/mmbtu. The LRAC is the sum total of gas supply costs and gas transportation costs, and includes both indigenous gas fields, LNG imports and LNG Swaps. The weighted average total economic costs of gas is estimated at USD 8.02/mmbtu.

FURTHER EXPLORATION AND INVESTMENT

Myanmar has attracted interest for investment in its oil and gas industry due to its strategic location, size and stock of natural recourses (UKIT). However much of Myanmar's offshore gas

35 (Agha et al., 2016)

potential remains unexplored. An important project has been the auctioning of 30 O&G exploration blocks in April 2013, 20 of which were awarded to winning bidders. One of the firms to win an exploration block was the Norwegian firm Statoil (AD-10).

Deepwater areas in Myanmar have been largely unexplored. There is currently limited accessible data and the geology is fairly complicated. Little investment in these areas were made due to previous sanctions. Recently Woodside discovered a 129m (meter) gas column with 32m net pay in the A-6 block. In addition Woodside also discovered a 64m gas column with 62m net pay in the AD-7 block. Woodside is currently preparing for an appraisal for these blocks[36]. AD-7 is relatively shallow and could tie in to the Shwe pipeline, but A-6 is more than 2000 meters in depth and will be more complicated and expensive.

Offshore discoveries in Myanmar may prove to be fairly significant. The basin is fairly large and has a proven petroleum system and thick sedimentary deposits. However the basin continues to suffer a lack of investment, particularly in deep waters. There are small chances of discovery and the projects are fairly high risk. Myanmar lacks the necessary infrastructure and offshore supply base, which is likely to increase costs significantly. There are few service companies and it will be difficult to acquire skilled labor.

However the major challenge for investment, according to commentators, are the fiscal terms. In the current production sharing contract regime, the average government take from production sharing contracts is 77% and the take on fields with more than 900 mmscfd in production is 90% for shallow water wells (<2,000m) and 80% for deepwater wells (>2,000m). [37] Commentators note that the fiscal terms for shallow water and deepwater fields are not differentiated enough. In addition commentators[38] note that some fields might require wells significantly greater than 2000m. These wells would be more complicated and costly, yet there is no differentiation in the current fiscal regime. Therefore commentators argue that under the current fiscal terms Myanmar will struggle to attract investment.

36 (Myanmar-Norway Business Council, May 2016)

37 (Agha et al., 2016)

38 Interview February 2016

However, even if the fiscal regime was reformed, thus attracting investment and discoveries, a question would be if Myanmar would be able to offtake the gas produced? While the government has imposed a 25% minimum on domestic allocation, the current availability of pipeline transmission infrastructure and generation capacity is insufficient for large quantities of gas. The likely scenario in this case, according to commentators, is that the gas would be exported to neighboring countries. If Myanmar was to follow through with developing coal-fired generation capacity, thus locking in its energy system to long-term coal projects and imports, then it would be unlikely able to develop the capacity in its natural gas sector to offtake natural gas production.

Therefore Myanmar needs to consider proper recourse management when developing its energy sector. Natural Gas is not only a clean and inexpensive fuel for power generation, but also an important feedstock for a number of industries including fertilizers and petrochemicals. Importing LNG may be an interim solution until new gas discoveries come online, and will enable the development of domestic natural gas infrastructure.

CASE STUDY – BANGLADESH

In order to illustrate the threats energy shortages pose to Myanmar electricity sector, it would be useful to illustrate through a case study of Bangladesh. In the past decade Bangladesh has faced an extreme shortage of electricity. Today Bangladesh has only a 41% electrification rate. Like Myanmar, Bangladesh has possible natural gas reserves, but has faced significant production shortages. Today, power cuts are frequent in Bangladesh and power supply is insufficient and irregular, the supply of power has caused damage to domestic, agricultural and industrial sectors.

Bangladesh had planned to resolve its energy crisis through the promotion of coal-power and hydro-power, but none of the coal-fired power projects have had progress. Similar to Myanmar, Bangladesh developed an energy master plan to increase coal-fired capacity from 2% to 50% of the energy mix. Namely issues surrounding environmental health impact assessments, regulations and public opposition has stalled a number of these projects. Projects like the 1,320 MW Rampal power plant, which would use imported coal from India, was lambasted for having 62% higher generation costs than the average cost of electricity production and hiding the true costs through massive subsidies.[39]

In order to solve the immediate energy crisis, Bangladesh Authorities initiated a Quick Rental Power Plant (QRPP) for oil-dependent power plants[40]. Most of the contracts where short-term, running from three to five years. However the government failed to anticipate impacts of price increase on liquid fuel, the government was obligated to purchase the rental power at a high cost and sold at the regulated bulk tariff. The Bangladesh Petroleum Corporation incurred a loss of BDT 10 billion in 2011-2012. The developers in the program were not qualified, and failed to set up the plants within time or even within extended periods, and the projects used inefficient second-hand equipment and generated much less than the rated capacity of power. The result was that the QRPP program generated huge losses for the government as the government was forced to subsidize the high electricity prices. Today Bangladesh Electricity System loses nearly USD 1 billion per year. HFO and Diesel fuels account for 65% of fuel consumption costs in the government budget and the average power generation costs from HFO are USD 0.23 (BDT 19.3) per Kwh.

Myanmar risks falling in the same energy trap as Bangladesh. Already in July 2016, Myanmar launched an emergency tender for 300 MW for five years for Yangon, which was won by Karpowership, will run of heavy fuel oil. The Karpowership will be located near Thanlyin, where currently residential development is occurring. According to one informant, Oil-fired power plants such as Karpowership produce similar emissions as a dozen large containers ships which is hazardous for local health. As Yangon faces energy shortages in dry seasons, emergency tenders like this are likely to continue, and take a heavy toll on the energy budget.

In the last few years, however Bangladesh has been in negotiations with Excelerate regarding the Moheshkhai LNG project, which received a debt financing package of USD 126 million from the IFC. The terminal will have 138,000 cbm of storage and is expected to be in service by mid-2018. Bangladesh is also set to finalize a second FSRU project. Importing LNG can therefore be an easier to implement and quicker solution to solving Myanmar's energy needs. Pollution from LNG projects are negligible.

39 (Institute for Energy Economics and Financial Analysis, June 2016)

40 (Islam et al., 2014)


PGN FSRU LAMPUNG

3. Floating Storage and Regassification Projects

Myanmar is likely to face a gas shortage in the next few years. Importing LNG through a FSRU could be an affordable solution for importing natural gas. LNG has become considerably more affordable, particularly in regards to spot market prices. However, it is noted that there are a number of challenges for a large FSRU project and it is uncertain if the project could meet short-term gas supply deficits.

Expense Item	Cost (USD million)
Construction/Equipment Cost Total	514
FSRU	278
Jetty	82
Pipeline	154
Consulting Cost	15
Interest in Construction period and handling fee	69
Tax for Capex	25
Initial Cost Total	624

Table 4: Summary of Japan Research Institute, Mitsui O.S.K Lines Ltd., JGC Corporation and Sumitomo Mitsui Banking Corporation Feasibility's Study for Introduction of LNG receiving Facilities in Myanmar.

JAPANESE FEASIBILITY STUDY

In February 2014, the Japan Research Institute, Mitsui O.S.K Lines Ltd., JGC Corporation and Sumitomo Mitsui Banking Corporation released the "Feasibility Study for Introduction of LNG Receiving Facilities in Myanmar"[41]. The study outlines a possible site location, FSRU ownership options, jetty design, pipeline construction, financing, and LNG procurement. The total investment cost was estimated at 624 USD million and annual running cost at USD 24 million.

The regasification capacity for the proposed FSRU was 360 mmscfd. The FSRU was proposed to be located 100 km offshore, operating for 20 years. The operating cost estimate was at LNG prices at a USD 14/mmbtu gas cost. The research and construction period for the project was five years. However, according to commentators[42], little progress was made after the feasibility study and the project went mostly silent. It is unclear why the project did not move forward.

WORLD BANK SPONSORED FSRU PROJECT

The World Bank is currently providing technical assistance on a proposal for a FSRU. The actual LNG volume is still being discussed as potential LNG demand is still uncertain. In 2016 the World

41 (Japan Research Institute)

42 Interview February 2017

Bank commissioned MJMEnergy Ltd. to carry out site location study. MJMenergy was commissioned to study three general areas requested by MOGE. As described later, commentators have questioned why MOGE has specifically requested these sites. These areas included

- Site 1: Kyuak Phyu in Rakhine State
- Site 2: Nga Yoke Kaung in Ayeyarwady state
- Site 3: Kalagauk Island in Mon State

The World Bank also requested that two new sites be studied:

- Site 4: Gulf of Marataban, 95 km south of the mouth of Yangon River
- Site 5: Kanbuak, North East of the island of Heize Bok

The site concluded that site 1 (Made Island) in the Rakhine State (Close to Shwe Oil Terminal) was a good marine site and could connect to the Shwe Pipeline, but a new 557 km pipeline would need to be built towards Yangon which would be fairly costly. Site 2 (1 km offshore at Southern Headland) in the Ayeyarwady state was the cheapest, but there are environmental concerns regarding coral and sea life and is likely to be opposed. Site 2 would require a 230 km pipeline. Site 3 (Bentick Sound) is the best marine site and wouldn't require dredging (400 km), but the

Figure 6: Map showing proposed FSRU sites discussed. Source: own creation

Site	Capital Investment USD mill	Operating Expense USD mill/pa	Discounted Expenditure USD mill
Site 1	826	66	1,032
Site 2	350	80	682
Site 3	668	80	948
Site 3 (Subsea pipeline)	387	81	720
Site 4	313	81	649
Site 5	855	15	808
Site 5 (Subsea pipeline)	640	15	621

Table 5: The World Bank is currently providing technical assistance on a proposal for a FSRU. This table below shows the capital and operating costs for various locations. Source: MJMenergy

pipeline route to Yangon is long. Site 3 could alternatively use a 170 km subsea pipeline option across the Gulf of Martaban. Site 4 would have the lowest discounted cost, but there is uncertainty in relation to the cost of an offshore pipeline and the breakwater. Site 4 would need a 90 km offshore pipeline and 50 km onshore pipeline. Site 5 could use a refurbished LNG carrier and 540km land-based pipeline to Yangon, based on a cost sharing scheme with Thailand (56.25% MOEE, PTT et al 43.75%). Site 5 could alternatively use 265 km of offshore pipeline. The study notes that site 5 is only feasible with cost sharing with Thailand.

The table below shows the capital and operating costs. Capital costs include mooring, dredging and pipeline infrastructure, while operating costs include FSRU lease, fixed and variable costs. The study notes that the costs for using offshore pipelines are uncertain and can increase implementation schedules.

DAWEI FSRU PROPOSAL

The Italian-Thai Development PCL is in discussion with Myanmar Authorities to build a LNG import terminal at the Dawei Industrial Zone. The Dawei project, however, has long been delayed and the project is uncertain and little news regarding the terminal has come out lately. However the Dawei industrial zone has faced widespread local opposition who opposed forced relocations and environmental threats.[43] It is also question if the project would bring benefits to the local communities. The project is highly beneficial to Thailand as it solves the problem of the lack of a deep water sea-port access which would give Thailand maritime access to India, Middle East, Europe and Africa. However it might be more beneficial for Myanmar to develop its deep water sea port closer to industrial districts such as Kyaukpyu in the Rakhine State, which is supported by the Chinese. Myanmar might also choose to develop its Thilawa industrial district, which is supported by Japanese partners. It is unlikely that a Dawei energy project would have significant energy development benefits beyond the industrial district itself.

PTT FSRU

PTT is also currently studying a 3 MTPA FSRU to be located in Myanmar in the Mon State in order to mitigate against lower gas imports that currently supply power plants in east Thailand. PTT is currently conducting a feasibility study on this power plant that they presented in February. According to commentators, PTT will have to determine the costs of building the terminal and paying for the pipelines on the Myanmar side, in addition to any taxes and the price at the order. PTT will have to weigh this option against building a terminal and pipelines in Thailand. It is unsure if any of the regasification capacity would be allocated to Myanmar and what a possible sharing agreement would look like.

KEY CHALLENGES TO THE LARGE FSRU OPTION

Importing LNG through an FSRU can be a cost-effective and immediate solution to a short-term energy supply gap in Myanmar. Experience from global FSRU projects show that, in the right conditions, projects can be "fast-tracked" within one to two years. However, a number of challenges are likely to delay or hamper efforts to establish LNG infrastructure and procurement in Myanmar. Such challenges include institutional gaps in energy governance, hinders in development assistance, lack of commercial structures, lack of development in installed capacity in electricity generation, lack of support infrastructure, and land right and environmental and social impact issues.

43 http://thediplomat.com/2016/04/myanmar-the-dawei-special-economic-zone/

Methodology

This section is based on interviews with commercial and legal consultants and firms that have worked closely with Myanmar energy projects and Myanmar energy authorities. The sources are made anonymous. While the sources have excellent credentials, the author cannot guarantee the reliability and validity of the information. Some of this information, however, can be triangulated with documentation and articles written online.

Institutional Gaps after Ministry Merger

One of the first acts of the post-transition government was to merge the ministries of electric power and energy on 30 March 2016. Before the merger, interviewed firms had noted that the inefficiency of the bureaucracy of Myanmar, that required approval from several different ministries for projects. The energy sector was fragmented into several ministries with overlapping responsibilities for policy-making, regulation, planning and supervision. However, despite the merger, commentators have the impression that the new ministry is split along the lines between oil and gas, and electricity generation.

The former Ministry of Energy Permanent Secretary, U Pe Zin Tun, was installed as the head of new ministry. U Pe Zin Tun's was contested due to lack of technical experience in electricity generation[44]. Some commentators suspected that U Pe Zin Tun may have been hampering reform processes in the new ministry. However U Pe Zin Tun has taken leave and replaced by the former minister of construction, U Win Khaing in June 2017. Nevertheless, there have been a number of challenges regarding the intermingling of policy and synergy between the two sides of the ministry.

In particular, commentators suspect there is a lack of clarity over whom LNG falls under within the new ministry. The challenge is that the former Hydropower Generation Enterprise dealt traditionally with large-scale electricity generation projects, while the Myanmar Oil and Gas Enterprise dealt with natural gas retail. The division of responsibility for structuring LNG arrangements is notably absent. Commentators suspect that leadership is split along old institutional lines, and the leadership needed to

44 (Lone, Thank, Lwin, & Shin, 5 April 2016)

restructure and reform the ministry is absent. MOGE, for example, seems to favor pipeline transmission for gas supply from the FSRU site to Yangon. These gas transmission pipelines, however, would require considerably high capital expenditures. However, a possible alternative would be to build a power plant near site and build high-voltage transmission lines to Yangon. Commentators suspect that parts of the ministry operate in silos and leadership is failing to develop cooperation in the Ministry.

The new ministry is also hampered by a persistent technocratic regime and hierarchical arrangements, which has left ineffective decision-making capacity in the organization. Commentators suspect that while low-level, trained staff has sufficient technical expertise, there is little decision-making on commercial structuring. Senior officials lack experience in the industry and are unable to ask adequate questions and make sound decisions based on the experience of lower-level staff. Commentators claim that many of the senior officials in the ministry are ex-military officials as traditionally the military was integrated in civil service, thus reinforcing the hierarchical arrangements and the lack of decision-making on key issues.

Hinders regarding Development Assistance

In 2013, the World Bank initiated the Myanmar Electric Power Project for Myanmar with a total project cost of USD 140 million, with the aim to increase capacity and efficiency of gas-fired power generation and strengthen the institutional capacity of the ministry of electric power and Myanmar electric power enterprise. The project included a component of USD 130 million expansion of the Thaton GT station in the Mon State into a high-efficiency CCGT power plant. The second USD 10 million component included Technical Assistance and Advisory Services. The second component included a development of the National Electrification plan, Financial Analysis and Forecasting, Economic Valuation of Natural Gas, and a review of Electricity Tariffs and Subsidy Mechanisms, and capacity building on procurement procedures.

An important part of the project has been to review the option of importing Liquid Natural Gas to cover shortfalls in domestic natural gas supply. A FSRU option has been reviewed, but commentators have noted a number of institutional gaps regarding structuring the commercial arrangements. Informants suspect that the World Bank has been stymied in the process of developing institutional competence.

The challenge is that the WB operates at a level below direct-input on decision-making processes. In some cases, the WB is not involved or is not aware of decisions being discussed. A notable example is the proposed site locations from the Ministry for the FSRU, which has been unclear to most stakeholders, including the WB, on the screening process to determining the site locations. It is unclear why other site locations were not chosen.

Informants have noted, for example, that a USD 100 million, International Finance Corporation project to build a 225 MW CCGT power plant in the Myingyan Township in Mandalay Region has struggled to reach financial close that was planned in February 2016. The Myingyan project agreement was reached in 2015, and the PPA signed in March 2016. However the deal took more than two and half years to transact. However it is seen to be benchmark for Myanmar as the open tender process could be used to template further tendered transactions. Another project that has been delayed, commentators noted, was an IFC project to launch a tender for transaction advisors to the government. In September 2016 the IFC put out an EOI for transaction advisors for Myanmar and Sri Lanka, but when the issued the tender for December it was only for Sri Lanka and Myanmar had dropped out. Informants suspect that the IFC and the Government struggled to reach agreement on fundamental questions, particularly on what risks can be put to the side.

Hinders in development assistance are likely to delay LNG sector development in Myanmar as the government struggles to develop the commercial structure for the industry. Informants claim that the challenge is there are a number of development banks that compete to lend to development projects, and have therefore conflicts of interest when it comes to setting higher requirements for assistance. Development banks have therefore struggled to entrench themselves within the ministerial bureaucracies.

Challenges in Developing the Commercial Structure

Another noted challenge is that key decisions such as buyer, seller, owner, final paying for the asset, tariffs that don't reflect costs are not being addressed so far in the ministry. While a request for Expression of Interest (EOI) was released, commentators noted that there were over 200 submissions, and argued that the EOI gave little basis for evaluation as very little was defined in regards to questions on FSRU construction and leasing, LNG procurement, and power plant construction and operation.

There are also a number of laws that requires reform such as the outdated petroleum law and investment Laws. Currently there are few guidelines on storage and distribution/pipelines. There has been little clarity regarding who is currently revising the legal structure under the Ministry of Energy and what direction it will take, according to informants. However the sub-legislations in the legal structure would not require parliamentary approval, as the petroleum act gives the authority to the ministries.

Another key challenge is that current electricity tariffs are far too low to reflect the costs of LNG import. The challenge with low tariffs is that if the government is to put in Power Purchase Agreements with IPPs and investments, the debt service on such project will rise significantly. Residential tariffs range from MMK 35-50/kwh and Industrial Tariffs at MMK 75-150/kwh. Tariffs are currently barely enough to cover costs, but only because few investments have been made and energy infrastructure is old. If new investments are too be made and debt servicing will rise, then Tariffs must rise as well. For FY 2015-2025 the overall tariffs are estimated to be below the costs of supply by about MMK 300 billion. The government budget is not healthy, and electricity tariffs cannot sustain high power purchase costs unless they are raised significantly. Changing the Tariff structure, however, is likely to be politically challenging.

Credit risk is a large challenge for projects, as there is little track record in Myanmar regarding payment for electricity services. Interviewed firms have also noted the need for a sovereign guarantee, in a currency other than Myanmar Kyat, for large-scale LNG import projects in Myanmar. Doing so would significantly increase the bankability of projects. However, informants note that issuing a sovereign guarantee will be difficult, as it would require an act of parliament, which would be sent to the ministry of finance and then to the ministry of energy. The transmission program has been delayed for this reason according to one informant. The lack of government guarantees has been a large issue for several energy project to move forward. In the end, according to informants most large-scale projects are not bankable unless backed through a state-to-state arrangement as seen by projects backed by China or Japan. These projects, however, favor the utilization of Chinese or Japanese technology, and in the case of Chinese projects can often involve energy exports and the use of Hydropower or Coal. A main issue is that the government will need to set aside a large portion of their budget in order to guarantee projects and it is still unclear for the government on what projects should receive a sovereign guarantee according to one informant.

Delays in Developing New Electricity Generation Capacity

Another question that will prove difficult regarding LNG imports through a FSRU is a question of who will offtake the gas supply. Having a FSRU will require a power plant of considerable size to be able to offtake gas supply, and while there are proposals, there is not yet any bidding on such power plants. Therefore, until a bidding process for a power plant begins, it will be difficult to see how a FSRU project can go forward.

The only credible, large scale off taker is the power sector, or the electricity enterprises, so the question will resolve on how will they finance and buy power, and what sort of guarantee for power projects will be provided. However, getting a guarantee will require an act of parliament that is likely to slow down the process, the budget is passed annually and the government can guarantee any particular payments will be approved. The government has not issued such guarantees in the past, and a government guarantee can only be issued by the ministry for finance and planning within terms and conditions that have not been clarified. (Frontier). However informants have noted that there is a usually a clause akin to a purchase guarantee in IPP rentals from the government.

One major challenge has been the lack of additional new generating capacity under the previous government, many projects failed to materialize. With the exception of the 300 MW Karpowership project which was signed under an emergency tender in 2016, few new projects are scheduled to come online in the next five years, with the exception of the Thaton and Myingyan power plant projects. Before the previous government left office, five PPAs were signed. However commentators have noticed that few of these projects have gone further. The signing process for these projects was hurried, and few of the agreements have been able to attract investment. One major challenges is the lack of a standard PPA agreement framework, each PPA has been negotiated on an ad-hoc basis. However the Myingyan project, which was approved on an open tender process, is likely to serve as the standard for further PPA's.

There has been discussion of a 1,000 MW gas-fired power plant to offtake any eventual supply from the FSRU, but there has been little talk on who will build the power plant. There is also a question of whether it is necessary to build a new power plant or to focus on upgrading the existing power plants and gas transmission pipelines.

Lack of Supporting Infrastructure Development

One major challenge is that the electricity grid is old and inefficient, with too few transmission stations and power plants. Informants argue that frequent black-outs in Myanmar are not only the result of lack of generation capacity, but also inefficient substations and transmission. Little capital is also currently available to support the development of this support infrastructure. Therefore, commentators argue, that large-scale power development plans are likely to be delayed.

The largest cost associated with the FSRU project will likely be associated with necessary supporting infrastructures such as jetties and pipeline development. In the site location study the estimated capital investment costs (Mooring, Dredging, and Pipeline costs) for a leased FSRU project range from USD 350 million to USD 826 million on the sites studied. If new pipelines are needed for the FSRU project, then there is a serious issue on whether such pipelines could be developed in the time frame needed to meet Myanmar's short-term gas shortage.

Land Right and Environmental and Social Impact Issues

Commentators had a strong impression that building pipelines would be difficult due to right of way issues. The new democratic government is unlikely to use eminent domain laws in order to procure land for pipelines due to political risk. The NLD has previously called out against the systematic confiscation of land from residents under military rule. A number of land-grab cases are now under review, and the government is in a process of untangling land disputes. Commentators argue that the government needs to figure out a system for suitable compensation for land owners, however one challenge will be determining land-ownership. However there are several challenges.[45]

- Myanmar does not have detailed procedures on land acquisition and laws are outdated.

45 (Myanmar Centre for Responsible Business, March 2015)

The current legal framework is prone to abuse and has limited safeguards for property holders,

- Documentation can be hard to find, and some land-ownership is held customarily. The law does not recognize customary land rights and rights of those who lack formal documentation.
- The government might declare land vacant even if it is not
- There are no detailed regulations regarding specific compensation levels for land or on involuntary resettlement processes

It is likely therefore that there will be disputes, which could delay the project. Commentators have also noted that building transmission lines is likely to be less controversial than building pipelines as they have less environmental impact.

Procedures for Environmental and Social Impact Assessments are also likely to delay projects. EIAs have been conducted arbitrarily and on an ad hoc basis. New EIA procedures however were signed by the cabinet in 2016, however according to Aung (2017) , there are still some challenges regarding the practical implication and due diligence. Public participation is challenging and requires extensive periods of time to complete.


FANAFJORD

4. Alternative Solutions

A large FSRU project poses a significant number of issues that have yet to be resolved, thus underlying uncertainty regarding the short-term implementation of the project. Realistically a FSRU will be challenging to implement before 2022, according to commentators. It could be questioned if a large FSRU is needed to meet the gas supply deficit Myanmar is likely to face after 2020. Therefore an inquiry into alternative solutions is suggested.

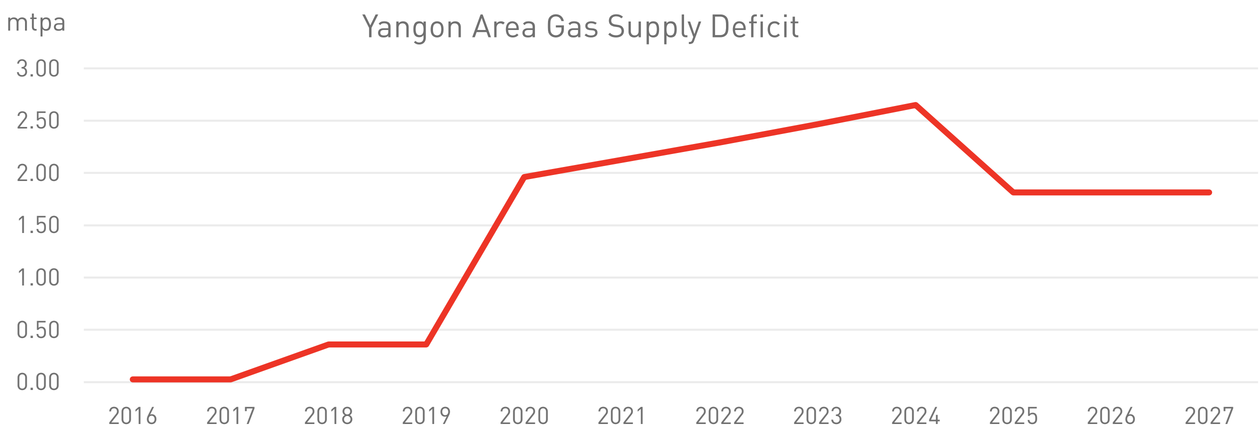

Figure 7: Calculated based on Gas Supply Deficit from the Daw Nyien Offtake Source: E.gen

The actual demand for LNG is fairly uncertain. Several reports have project widely different analysis. The JICA report projects no requirement for imports until 2020 and the EMP reports imply a requirement for LNG imports at very low volumes until 2027, reaching 1.4 MTPA in 2030. However these reports forecast large Hydropower and Coal-Fired development, which as explained before is unlikely in the short-term scenario. A METI 2016 report forecasts a much larger LNG demand, starting at 2.2 MTPA in 2020 and rising to 8.7 MTPA in 2030.

However, a more recent forecast by E.Gen, which estimates the demand of current and planned gas-fired power plants expects a peaking of 3.7 MTPA in 2025 and declining to 2.3 MTPA in 2030. While the large LNG import requirement is cited as a main reason for the FSRU project, the FSRU plans generally imply gas supply to the Yangon region. The Yangon region, which is supplied by the Yadana field through the Daw Nyien offtake has an expected LNG import requirement of 1.96 MTPA in 2020, peaks at 2.65 in 2024 and declines to 1.81 after production start on the Aung Shika field. The maximum import requirement will be 370 MMscfd. One commentator pointed out, regarding the FSRU project, that if the project might not realistically be developed until after 2022, and then new gas reserves come online in 2025 and 2030, then how is the FSRU going to reach its investment return ratio?

However, another issue that is not taken in account in the report is the current inefficiency of the gas transmission grid around Yangon, and that currently gas-fired power plants operate far below capacity. The E.gen report at least to the author's knowledge, did not account for upgrading existing power plants. Namely, how much could the supply gap be reduced if power plants in Yangon were updated to more efficient combined combustion turbines? According to one informant, the power plant in Thilawa that only operates with one of two turbines, due to the lack of gas supply. Upgrading the Thaton power plant using CCGT states improved thermal efficiency by 52% compared to 21% for the old plant. The new plant generates 2.5 times more power with the same gas consumption. In addition the transmission grid currently operates at a 23% transmission loss, upgrading the grid could significantly reduce the gas supply gap. Therefore more inquiry is needed to estimate how much the gas supply gap in Yangon could be reduced through improving efficiency.

Nevertheless, Myanmar will therefore need a solution that is quick to implement, is scalable, affordable, provides stable supply, and can easily be integrated with other energy sources and connected to the national grid. Small-Scale LNG solutions, Floating LNG solutions, and LNG-to-Power Solutions are argued to be an alternative that can solve the immediate power needs of Myanmar. These solutions can be located closer to demand centers compared to hydropower or FSRU projects. While the 9m maximum draft up to Yangon is too shallow for a large-scale FSRU, it would be sufficient for smaller vessels and barges.

According to commentators, there are a number of private parties with IPP contracts and five to six year contracts without upfront commitments in Myanmar. A number of Myanmar companies, many of whom are based in Singapore, work with these type of arrangements. Obtaining government guarantees for projects will be difficult, as they would have to be provided on a project by project basis and the timeline for procuring a project could be time-consuming.[46]

What is needed is an integrated chain of companies dedicated to delivering a complete LNG to power project. Instead of tendering for each aspect such as LNG sales, power plant construction, transmission lines, it is recommended that Norwegian firms formulate

46 (VDB Loi, April 2017)

an IPP project proposal and lobby to relevant stakeholders. Since the project is an IPP, is could be structured within a similar PPA framework to the Myingian project. Such a project could be implemented far quicker than a FSRU and such projects could be located close to demand centers. Thus the capital expenditures on expensive gas and electricity transmission infrastructure would be greatly reduced. Some firms have already considered plans for small and medium scale LNG projects in Myanmar.

- The Norwegian company, Blystad Energy Management, currently conducted a feasibility study for a 0.8 MTPA LNG-to-Power Barge that could be located near Thilawa. The terminal could generate 250 MW and supply 600,000 tons of LNG to the existing pipeline transmission grid. The project would require much less capital costs in support infrastructure than a FSRU project. The terminal would have 30 days of storage capacity.
- Engie and Shell have reportedly also looked at the 400 MW Thanlyin power plant and refinery on the east bank of Yangon River, as a possible site for a small-scale LNG supply.
- Wartsilia has also presented the possibility for an onshore LNG terminal to supply a 125 MW power plant with a LNG demand of 311,710 m^3 per year. The minimum storage size would be net 5,125 m3.[47]

Norwegian firms need to form a collaboration across the value chain, including electric power generation, in order to deliver an IPP power solution. According to informants, the Blystad Energy Management project could supply LNG at a per mmbtu price similar to the current contract price for domestic gas supply. The advantage of LNG to power projects, is that the power plants can be later supplied with domestic gas supply once production comes online. The project would only require reversing the pipeline flow direction and decommissioning the storage terminal. Blystad Energy Management would coordinate with a number of other Norwegian firms to develop the project.

This report therefore recommends that further inquiry is needed on the feasibility of covering that gas supply gap in Yangon by utilizing medium and small-scale LNG import facilities with shallow drafts that can be located closer to Yangon, thus requiring less investment in support

47 (Kenneth Engblom, May 2017)

infrastructure. The rates for the Blystad Energy Management project can be adjusted such that that prices are lower in the first few years, in order to give time for the government to increase tariff prices. These projects would require less capital investment, are easier to structure with the current fiscal framework.

SMALL-SCALE LNG COULD SOLVE GAS SHORTAGES AT VARIOUS OFFTAKES

While the LNG import requirement is highest for the Daw Nyien offtake, several other offtakes in Myanmar are forecasted to have gas supply gaps. An outlook of gas supply gaps at various offtakes in the current pipeline transmission grid was presented in the E.gen report.

- Ayadaw, Chauk, Kyaukse, Htuak Sha Bin and Mann are supplied from onshore gas fields and are projected to have small supply gaps of 1-2 mmscfd from 2020-22 onwards.
- Kanbauk, supplied from the Zawtika gas fied, will have a peak deficit of supply 50 mmscfd from 2020.
- Kyauk Phyu, Taung Thar, Yenanchaung and Belin supplied by the Shwe offshore gas field are not projected to have supply gas gaps.

According to informants LNG import infrastructure solutions developed in Yangon could eventually be equipped with a transfer arm for LNG containers for LNG trucks or LNG river barges. LNG trucks could be used to supply LNG to offtakes with small gas supply deficits. River barges could eventually deliver LNG to small-demand centers further up the Yangon river. A small-scale LNG import facility could be established near Kanbuak, and potentially be supplied via small LNG carriers.

LNG-BASED DISTRIBUTED GENERATION

A DNV-GL report[48] introduces the feasibility of utilizing LNG-based distributed power generation and micro-grids as an alternative to traditional solutions such as centralized grid extensions or diesel power-generation plants. As stated before micro-grids based on solar, wind or micro-hydro can support energy development, but can create large swings in load charges, which can create problems for the grid. LNG based systems that feed reciprocating gas engines could support such grids, in order to enable stable supply. In some cases, particularly regions located far from the national grid or where grid extension faces topographical challenges, LNG based systems

48 (DNV Clean Technology Centre)

may be more economical. Such projects are particularly viable in areas that have a concentration of power-demand from high-value businesses and industries such as resource mining and processing, tourism, or intensive agricultural or forestry activities. Satellite LNG storage facilities for 100-50,000 cbm can provide power for 0.5 MW to 100 MW plants for two weeks. Distribution is feasible via small-scale LNG carriers (5,000 to 30,000 cbm) or LNG trucks and river barges (30 to 50 cbm). Milk-runs, or multiple point delivery with a single barriers, can reduce logistics costs through larger-economies of scale. If a LNG terminal or FSRU is developed in Myanmar, then this can serve as a central hub for small-scale LNG coastal shipping or trucking. Otherwise Singapore can be used as a hub for small-scale shipping in Myanmar.


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5. Norwegian Firms and LNG Experience

Norwegian firms have long experience with LNG-related solutions. The Norwegian company, Moss Maritime, introduced the Moss Spherical Containment system, which has been the leading seaborne transportation system for LNG. Since then several Norwegian firms have developed a variety of scalable and cost-effective solutions for LNG storage, transport, regasification, and power generation. Norwegian LNG-related firms are well positioned to help support Myanmar's energy development goals.

Norwegian firms such as HOEGH LNG, BW LNG, and Golar LNG are world leaders in FSRU design, construction, deployment, and operations. Norwegian firms are also at the forefront of technical advisory services, and health and safety regulations in the LNG industry.

NORWEGIAN CAPABILITIES IN FSRU MARKET

- Safe and reliable long-term time chartered operation of FSRU compliant with international standards
- Sold experience in FSRU Procurement and Operation Management
- Supply of onboard regasification equipment
- Norwegian firms have experience with rapid deployment of FSRU infrastructure (BW maritime deployed a FSRU within five months of tender award). FSRU option offers a 50% reduction in lead time.
- Norwegian firms are flexible with vessel size and regasification capacity, and require lower upfront capital expenditure.

Norway has been a long-time exporter of Natural Gas since discoveries in the 1960s. Due to cheap and abundant hydroelectric recourses, little of Natural Gas production was directed to the domestic market. Rather most natural gas was exported to continental Europe and the UK.

However, a political push to embed natural gas in the domestic market led to a substantial rise in domestic natural gas consumption from 1994. Geographical challenges such as deep waters, scattered demand centers, and topographical barriers made building a domestic pipeline network challenging. Small-Scale LNG distribution via maritime and land transport was developed to supply LNG to industries and LNG-fueled maritime vessels.

Today, Norway has the most mature small-scale LNG business in the world. A number of firms have spun-off from this industry to offer cost-effective and redeployable small-scale import solutions to the global market. Norwegian companies have also developed sets of class rules and recommendations for new developments in the LNG industry. This includes LNG Transportation, Floating LNG Import Terminals, LNG-Fueled Maritime Transportation, and Small-Scale LNG Supply Chains. Norwegian firms also have experience in upgrading existing natural gas power plants and building energy-efficient replacements. Norwegian firms have designed a number of solutions for gas-fired reciprocating and CCGT power plants.

NORWEGIAN CAPABILITIES IN LNG DISTRIBUTION, IMPORT AND POWER GENERATION

- Co-developing modular satellite LNG receiving facilities.
- Co-developing Gravity-based and floating LNG-to-power solutions
- Supplying efficient storage systems for small-Scale LNG vessels and FSRUs
- Sharing experience on Ship-to-Ship Ops
- Conducting feasibility and safety studies for LNG ship-to-ship transfer
- Supply equipment for LNG ship-to-Ship Transfer e.g. cryogenic hoses.
- Pre-feasibility and feasibility studies for LNG based power generation
- Preparation of complete commercial and technical tender documentation

- Environmental and Social Assessment reporting:
  - Commercial and Technical Advisory Services related to LNG value chain
  - Concept Selection
  - Tendering Process
  - Design
  - Risk Analysis
  - Financial Assessments
  - Third Party Verification Studies


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Appendix

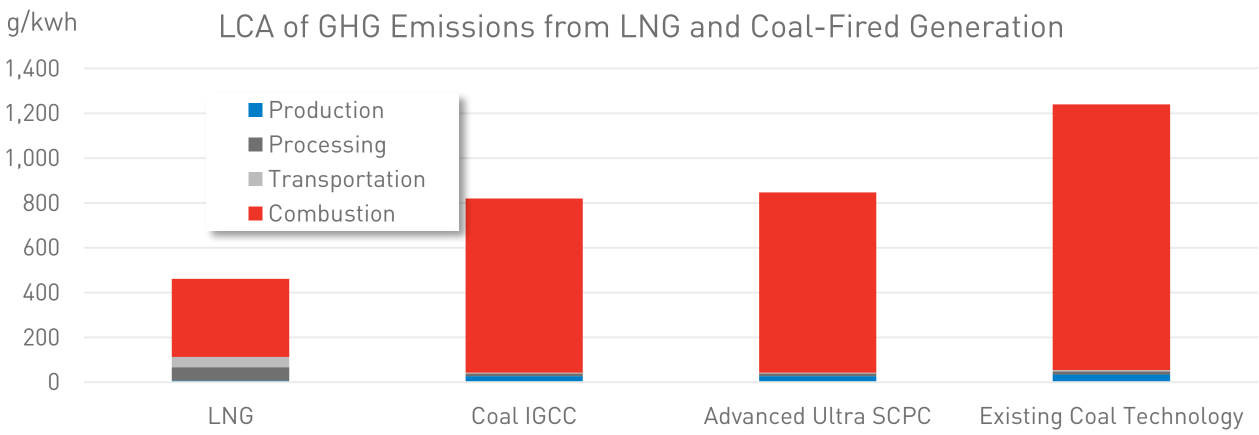

Figure 8: Graph showing LNG life cycle significantly reducing emissions as compared to existing coal technology. Source: Pace Global, 2015

THE COSTS OF COAL-POWERED ENERGY GENERATION

Proponents claim that coal-fired power plants could solve Myanmar's energy needs and keep electricity generation costs low. However, a 2015 U.S Department of Energy Report shows that at a coal price of USD 2.94/mmbtu breaks even with a natural gas price at USD 10/mmbtu. In addition, there are a number of externalities and risks associated with coal-fired power generation. While proponents claim that externalities can be managed through pollution mitigation controls, such systems also generate large amounts of waste that must be disposed of properly. In addition, the more advanced the pollution mitigation the systems, the larger the costs for power generation. Pollution mitigation also does not account for greenhouse gas emissions and does not utilize any methods for carbon capture and storage. The first graph below shows that LNG life cycle significantly reduces greenhouse gas emissions compared to existing coal technology. The second graph below compares pollutants and cost of electricity (COE) between natural gas and coal-fired power plants.

It is important to also account for the externalities associated with Coal-Fired Power Generation, that when taken account for, dramatically increase the costs. Epstein (2011)

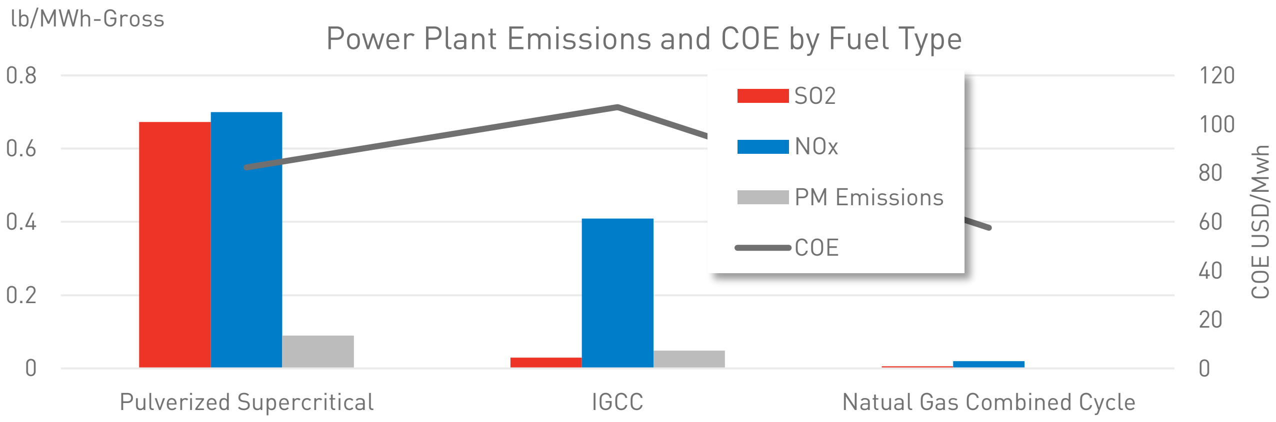

Figure 9: As represented in the graph, supercritical coal power plants produce considerable more pollutants than natural gas fired power plants. The Supercritical plant case is modelled with wet flue gas desulfurization, Low NOx burners, and Selective Catalytic Reduction. While IGCC technology might mitigate such pollutants, the costs rise significantly compared to natural gas. Fuel costs in this model are set at USD 40.7/Mwh for natural gas compared to USD 24.6/Mwh for Coal.[1] Source: National Energy and Technology Laboratory, 2015 a&b

has outlines a number of externalities associated with coal-fired combustion including:

- Damage to farmlands and crops due to combustion pollution
- Hospitalization costs resulting from increased morbidity in coal communities
- Climate change due to CO_2 and NO_x emissions
- Corrosion of buildings and monuments from acid rain
- Visibility impairment from NO_x emissions
- Environmental contamination as a result of heavy metal pollution
- Higher frequency of sudden infant death syndrome
- Impacts of acid rain
- Environmental impacts of ozone and particulate emissions
- Soil contamination
- Destruction of marine like from mercury pollution
- Freshwater use in coal-fired power plants

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
bcf	Billion Cubic Feet
bcm	Billion Cubic Meters
BDT	Bangladesh Taka
CCGT	Combined Cycle Gas Turbine
CO_2	Carbon Dioxide
DG	Distributed Generation
EOI	Expression of Interest
E&P	Exploration and Production
FID	Final Investment Decision
FSRU	Floating Storage and Regasification Unit
Gwh	Gigawatt Hour
HVTL	High Voltage Transmission Line
IGCC	Integrated Gasification Combined Cycle
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
Kwh	Kilowatt Hours
LCNG	Liquefied-Compressed Natural Gas
LNG	Liquefied Natural Gas
m^3	Cubic Meter
mmbtu	Million British Thermal Unit
MMK	Myanmar Kyats
mmscfd	Million Standard Cubic Feet
MMcm/d	Million Cubic Meters Per Day
MOE	Former Ministry of Energy (now MOEE)
MOEE	Ministry of Electricity and Energy
MOEP	Former Ministry of Electric Power (now MOEE)
MOGE	Myanma Oil and Gas Enterprise
MoU	Memorandum of Understanding
MTPA	Million Tons Per Annum
MW	Megawatt
NEMC	National Energy Management Council
NEP	National Energy Plan
NLD	National League for Democracy
NGV	Natural Gas Vehicle
NO_x	Nitrogen Oxides
O&G	Oil and Gas
PPA	Power-Purchase Agreement
SO_2	Sulphur Dioxide
SPA	Sale and Purchase Agreement
SPP	Small Power Producer
tcf	Trillion Cubic Feet
TPA	Third Party Access
Twh	Terawatt Hour
WB	World Bank
USD	United States Dollars

FUTURE GAS DEMAND IN POWER PLANTS IN MYANMAR

Power Plant	Source of Data/Estimates	Avg Daily Consumption in 2020/21 (mmcf/d)
Kyaung Chaung Gas Turbine	MOGE	2.1
Kyauk Phyu Gas Turbine (V-Power)	MOGE	8.8
APR GEG (Kyauk Se)	MOGE	0
Ahlone Gas Turbine	MOGE	66
Toyo Thai Gas Turbine (Ahlone)	MOGE	
Ywama Gas Turbine	MOGE	59.5
Ywama EGAT CCGT	MOGE	
Hlawga Gas Turbine	MOGE	50
MCP Gas Engine (Hlawga)	MOGE	
Shwe Taung Gas Turbine	MOGE	13.3
Myan Aung Gas Turbine	MOGE	2.9
Mawla Myaing Gas Turbine	MOGE	2.3
Tha Htone Gas Turbine	MOGE	9.7
Thaketa Gas Turbine	MOGE	27.0
Max Power (Thaketa)	MOGE	
UPP (Ywama) GT/GE	Electricity Master Plan	12
Myanmar Lighting (Malamyine)	Electricity Master Plan	43.7
Kanbauk GE	Consultants Estimates	1
Aggreko (Tanintharyi) GE	Consultants Estimates	16
Myingyan	MOGE	31.5
Thilawa (Yangon) GT	Consultants Estimates	12
Be One CCGT (Hlawga)	Electricity Master Plan	38.3
HDL CCGT (Hlawga)	Electricity Master Plan	38.3
IPP CCGT (Ayeweyarwdy)	Consultants Estimates	56
Thaton CCGT	Consultants Estimates	18.2
Eden (Thaketa) CCGT	Consultants Estimates	12.2
BKB CCGT (Thaketa)	Consultants Estimates	30.4

UREC CCGT (Thaketa)	Consultants Estimates	16.6
Kanbuak CCGT	Consultants Estimates	30.4
Total		**598.2**

Table 6: Future gas demand in power plants in Myanmar. Source E.gen

PLANNED GAS-FIRED POWER PLANTS IN MYANMAR

Power Plant	Installed Capacity (MW)	Year Built/Commissioned	Supplying Field
Myingyan	225	2015-2016	Shwe
Thilawa (Yangon) GT	50	2018	Yadana
Be One CCGT (Hlawga)	200	2020-21	Yadana
HDL CCGT (Hlawga)	200	2020-21	Yadana
IPP CCGT (Ayeweyarwdy)	400	2020-21	Yadana
Thaton CCGT	120	2018-19	Zawtika
Eden (Thaketa) CCGT	80	2020-21	Zawtika
BKB CCGT (Thaketa)	200	2020-21	Zawtika
UREC CCGT (Thaketa)	109	2018-19	Zawtika
Kanbuak CCGT	200	2019-20	Zawtika

Table 7: Planned Gas-fired power plants in Myanmar. Source E.gen

GAS DEMAND AT VARIOUS OFFTAKES

Gas Demand (units)	2016-17	2019-20	2020-21
Ayadaw	2.1	2.1	2.1
Chauk	1.5	1.5	1.5
Kyaukse	1.6	1.6	1.6
Htauk Sha Bin	0.8	0.8	0.8
Mann	1.5	1.5	1.5
Nyaung Done	9.2	9.2	9.2
Myaungdagar	7.7	7.7	7.7
Ywama	15.6	15.6	15.7
Kyauk Phyu	8.8	15.1	15.1
Taung Thar	31.5	31.5	31.5
Yenanchaung	33.2	33.2	33.2
Belin	11.6	11.6	11.6
Daw Nyien	253.8	300.6	475.9
Kanbauk	115.7	146.1	146.1
Total	**494.6**	**578.1**	**753.5**

Table 8: Gas demand at various offtakes. Units in mmcf/d. Source E.gen

NORWEGIAN LNG COMPANIES AND INTEREST ORGANIZATIONS

Terminals, Transport and Distribution

- BW LNG
- Connect LNG
- Gasnor/Shell
- Gassco
- Golar LNG
- Gravifloat/Semcorp
- Höegh LNG
- I.M. Skaugen
- Kanfer Shipping
- Knutsen OAS
- Liquiline LNG
- Norconsult
- Skagerak Naturgass
- Skangass
- Statoil

Shipping Companies

- Awilco
- BW LNG
- Golar LNG
- Höegh LNG
- I.M. Skaugen
- Jahre LNG

Shipping Companies (Users)

- Eidesvik
- Fjord 1
- Fjordline

Bunkering

- Gasnor/Shell
- Knutsen OAS
- Liquiline LNG
- Skangass
- Wärtsilä/Hamworthy

Storage and Engines

- Aker Solutions
- Kanfer Power
- Light Structures
- Mitsubishi
- NLI
- Rolls Royce
- Torgy LNG
- Wärtsilä/Hamworthy
- Wilhelmsen Marine Service

NORWEGIAN LNG COMPANIES AND INTEREST ORGANISATIONS (CONTD.)

Equipment Suppliers

- Aker Solutions
- Fiskerstrand Verft
- Kongsberg Maritime
- LMG Marine
- Multiconsult
- Siemens
- SINTEF/MARINTEK
- Skipsteknisk AS
- TTS Group
- Wärtsilä/Hamworthy

Other LNG Stakeholders

- Blystad Energy Management
- Clarksons Platou
- DNV GL
- Export Credit Norway
- Fearnley LNG
- The Norwegian Export Credit Guarantee Agency (GIEK)
- Innovation Norway
- Network LNG Norway
- Norwegian Energy Partners
- Norwegian Maritime Authority
- Norwegian Maritime Exporters
- SINTEF/MARINTEK

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