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Electricity Demand and Supply in Myanmar

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This research paper was written by David Dapice (David_Dapice@harvard.edu), of the Ash Center for Democratic Governance and Innovation at the John F. Kennedy School of Government, Harvard University, following a trip to Myanmar from October 20-November 19, 2012. It provides an update and expansion on the paper "Electricity in Myanmar: The Missing Prerequisite for Development" written in May 2012. *The views expressed herein are the author's alone and do not necessarily reflect those of Proximity, the Government of the Union of Myanmar, or Harvard University.* Funding for the study was provided by the Royal Norwegian Government. This study, along with other recent Ash-Proximity reports on Myanmar, is posted at http://www.ash.harvard.edu/Home/Programs/Institute-for-Asia/Publications/Occasional-Papers

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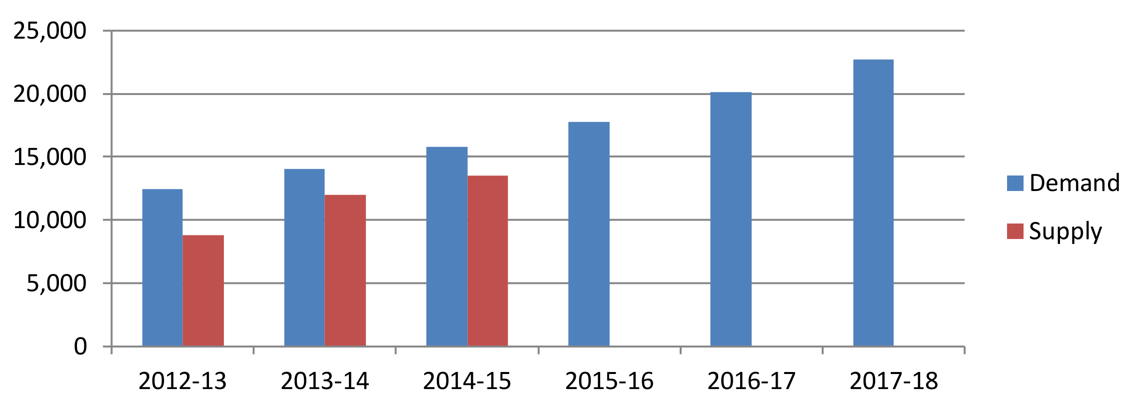
Background

This is the second in a series of papers on electricity in Myanmar, the first having appeared in May 2012. (Available at: http://www.ash.harvard.edu/ash/Home/Programs/Institute-for-Asia/Publications/Journal-Articles-Occasional-Papers) It makes use of new information on electricity, gas, pipelines and other data to focus on the Yangon region while still discussing the national supply and demand picture. Conclusions and suggested actions are presented.

Starting from Behind

The Asian Development Bank (ADB) recently released an excellent report on Myanmar's energy sector.[1] In it they presented estimates of future demand growth by the Ministry of Electric Power for electricity. They show demand doubling from 12,459 million kWh in 2012-13 to 25,683 million kWh in 2018-19, a compound rate of growth of 13% a year.[2] However, the actual production in 2012 appears to be only 10,000 million kWh, and it is unlikely that moving to 2012-13 will raise the total much beyond 10,500 million kWh. Of this output, about 1700 million kWh will be exported. (Electricity exports exceeded 1700 million kWh in both 2010 and 2011.) So, the likely electricity output in 2012-13 available for domestic use will be 3659 kWh below ***this year's*** demand estimate. *Production for domestic use would have to jump by 42% to equal the expected demand.* This is a massive shortfall and demand grows by over 1500 million kWh in 2013-14. So for 2013-14, supply net of exports would have to grow by nearly 5200 million kWh to account for the existing shortfall and projected growth, or by nearly 60% over 2012-13.

Projected Demand and Domestic Supply of Electricity in Myanmar, million kWh



Note: Graph shows total electricity output less exports. Exports will be reduced in 2013-14.

[1] "Myanmar: Energy Sector Initial Assessment," Asian Development Bank, October 2012

[2] The assumed growth rate of real GDP is 10.5% and of population is 1.1%. This would give an electricity/GDP elasticity of 1.25, far less than normal. (Vietnam's electricity grew nearly twice as fast as real GDP.) However, if actual GDP growth is only 6-7%, the assumed demand growth is more in line with regional experience and given the President's speech in which growth of 7-8% was a target, we can accept the electricity projections.

Adding Capacity

The proposed short term measures to boost power production include more purchases of power from Shweli-1 hydropower plant (100 MW base and 100 MW additional requested) from its existing 200 MW; and improving a number of gas turbines to add 110 MW of capacity. In terms of million kWh, 200 MW of Shweli-1 capacity would produce 1340 million kWh and 110 MW of gas turbines should produce about 800 million kWh, for a total of 2140 million kWh to be added, while the shortfall started at 5200 million kWh in 2013-14 so there would still be a 3000 million kWh deficit in the next year. When possible, this deficit will be partly offset by diesel generators costing 30-40 cents per kWh.

Longer term, there are plans to increase gas-fired electricity by 450 MW by 2015, doubling the firm gas capacity. Getting enough natural gas to fuel this extra capacity may prove difficult. The Southeast pipeline leading from offshore fields and then on land north through the Mon state to Yangon is reported to have corrosion problems and can only deliver a fraction of its rated capacity, although repairs are apparently being done on an unknown timeline. Other pipelines going direct to Yangon from offshore fields are close to capacity. Rebuilding the Southeast pipeline and increasing its capacity may be the best solution, although upgrading the Yetagun pipeline is also possible. In any case, Yangon needs more gas-fired electricity, since most hydro sources are distant and expensive to use.

After availability, the second question is if the current price structure of electricity would finance gas-fired electricity. Existing gas turbines appear to use **twice to three times the energy of newer gas turbines and combined cycle units** and thus raise the cost of gas-fired electricity far above the current price. Installing modern equipment, especially combined cycle generators, would allow profitable sales of power at about ten cents per kWh.

Box: Why Is Gas Fired Power in Myanmar So Inefficient?

The ADB report puts natural gas use for electricity generation at 41.23 billion cubic feet in 2011 and the Selected Monthly Economic Indicators puts gas-fired electricity output in 2011 at 2.094 billion kWh. This works out to 19.7 cubic feet per kWh or 20 thousand BTU per kWh.[1] Modern single cycle gas turbines use 10-11 thousand BTU per kWh and modern combined cycle gas generators use 6- 7,000 BTU per kWh. *Thus, gas generators in Myanmar appear to use about twice as much gas as modern single-cycle gas turbines and three times as much as modern combined cycle gas generators[1].* With gas costs of $10 per thousand cubic ft, the inefficiency means that the fuel cost per kWh of gas-fired power is 20 cents in Myanmar instead of 10 cents with a modern single cycle turbine or as little as 6 cents with a modern combined cycle generator. Given that these generators are run over 7000 hours a year, the “extra” fuel cost is $700 a year per KW of capacity for a single stage turbine and $1400 per KW for a combined cycle generator. Since the investment cost per KW of a new single cycle generator is less than $400 and about $1000 for a combined cycle unit, it would appear that ***the fuel savings alone would completely pay for replacing the existing turbines in less than one year!*** Loans should be available to finance such purchases and realistic charges (about ten cents per kWh for combined cycle power) would allow rapid recovery of the purchase price. Greater efficiency would also allow the same amount of gas to produce two to three times as much electricity as existing gas turbines, thus reducing the impact of restricted gas supplies.

[1] General Electric claims 61% efficiency or 180 kWh per million BTU on its latest “Flex Efficiency 50” combined cycle generators, but 2010 data from the U.S. Energy Information Administration suggest 155 kWh per million BTU and about 100 kWh per million BTU from modern single cycle turbines. One thousand cubic feet of natural gas contains slightly more than one thousand BTU.

Expansion of electricity in 2014-15 according to the ADB Report amounts to 1500 million kWh from a combination of hydroelectric and gas generators. However, projected demand will increase 1770 million kWh, so the deficit will increase again. There are no plans to provide adequate power for several years.

Prices and Costs

Right now, prices are set at 35 and 75 kyat per kWh, roughly four cents and nine cents in US$. If there is to be any hope of avoiding the use of diesel generators costing 30-40 cents per kWh, the price of electricity (aside from a "lifeline rate" for very modest residential use; see Appendix 1) should approach 90-100 kyats per kWh, or 10-12 cents per kWh at the current exchange rate. This should equal the cost of combined cycle power delivered to urban users with gas at $10 per million BTU.[3] Hydroelectric costs of 6-7 cents per kWh should be possible, even with foreign invested power. If lower rates of return are assumed for domestic hydroelectricity built by the government, hydroelectricity costs at the wholesale level could be even lower, though the cost would depend on the interest rate and the length of the loan. For example, if a kilowatt of hydroelectric capacity cost $1400 and was financed by an 8% loan over 20 years, the cost per kWh would be three cents, assuming 5000 hours of production per year.[4] Shorter loan periods, often preferred by private or foreign investors, translate into higher costs during the payback period. For example, if the cost of capital were 12% and the payback period shortened to ten years, the cost per kWh would increase to five cents. Of course, after the capital (or loan) was repaid, the five cent charge would be almost pure profit.

It is noteworthy that the **wholesale** cost of electricity in Yunnan, China is 0.5 yuan per kWh (7.9 cents) for industry and 0.379 yuan per kWh (6 cents) for residential users.[5] For delivered industrial power, it is necessary to add 2-4 cents per kWh, depending on how dispersed the customers are.[6] If Myanmar wants to be in a position to double electricity output every five or six years, it will have to price its electricity at the cost of the highest marginal (new) source, which will be either gas or private/FDI hydroelectricity. Keeping prices low means keeping blackouts and load shedding in place, since there will not be funds to supply or distribute the amount demanded. Indeed, there appears to be no plan to provide as much power as is officially projected for – a reflection of the current pricing policy.

[3] A payback period of 5-7 years is assumed for a loan to finance the purchase of a combined cycle generator; modest overhead and maintenance [O&M] costs are included. After the capital costs are retired, the wholesale cost per kWh, assuming $10 gas, should be only 6-7 cents per kWh. On December 11th, General Electric announced the purchase of single stage gas turbines (about 100 MW capacity) to be installed in 2013. Efficiency is 35% or 105 kWh per million BTU, equivalent to 9470 BTU per kWh.

[4] A $1000 loan at 8% over 20 years needs to pay $102 a year to retire the debt. If one kilowatt of capacity costs $1400, the annual payment for that amount of capacity would be $143. Assuming 5000 hours, 2.9 cents a kWh plus small maintenance and overhead costs, would be sufficient to cover costs. Some hydroelectricity is not fully available during the dry season and needs additional generating capacity to produce reliable power, increasing costs.

[5] http://www.12398.gov.cn/html/information/91652092X/91652092X201000066.shtml is the reference.

[6] Most utilities that cover costs charge retail prices that include 20-30% of their total costs delivering power, over and above the cost of generation. This includes both transmission and distribution.

How Much Gas?

The other important constraint, mentioned previously, is the supply of gas to the Yangon area. This is limited first of all by the amount of gas available from the various offshore gas projects close to Yangon (Yadana, Yetagun and Zawtika, for example) which also have export commitments and then by the carrying capacity of the pipelines flowing into Yangon. The Yadana pipeline to Yangon is at 150 million cubic ft a day and will rise to 200 Mft3/day by January 2014. The 20 inch Southeast Pipeline is supposed to be limited to 30 Mft3/day, much less than its design capacity, although some of its capacity should be regained as replacement pipe is installed.[7] Onshore gas is distributed throughout the nation and totals 70 Mft3/day. Shwe gas will flow through the Chinese pipeline and does not come close to Yangon – a separate pipeline would be needed or high voltage lines into Yangon from a generating location close to the Chinese pipeline, which should be in operation later in 2013. It will supply 100 Mft3/day to domestic markets, initially those close to the pipeline route. That means for Yangon in 2013, there will be only 150 to 200 Mft3/day[8], rising to 250 Mft3/day in 2014 unless either a Shwe connector or repair on the Southeast Pipeline is completed. (Using kerosene or diesel oil instead of natural gas has a similar cost impact as shifting to diesel engines – the costs are very high.)

Using Efficiency to Offset Limited Gas Supplies

A new combined cycle plant can generate 180 kWh from 1000 ft3 of gas; a modern single cycle turbine can generate 105 kWh and the average in 2011 was only 52.5 kWh from 1000 ft3. So, in 2014 the amount of electricity for Yangon from the gas available **would be** 45 million kWh a day from a combined cycle plant; 26.3 million kWh from a modern single cycle gas turbine and 13.1 million kWh from the 2011 fleet if they are not updated. ***The best way to reduce costs and increase electricity output is to put in place a new combined cycle plant. It would triple power output with the same amount of gas!*** The following table illustrates the amount of electricity that could be generated in the Yangon area from 100 million cubic feet a day from the three technologies – modern combined cycle, modern single turbine, and 2011 turbines. (It is assumed for simplicity that 1000 cubic feet contains one million BTU.)

Amount of Daily Electricity from Gas in Yangon Region from Three Types of Generators
Per 100 million cubic feet of natural gas per day

	Combined Cycle	Modern Single Turbine	2011 Generators
Million kWh	18	10.5	5.25

[7] The pipeline was built by a construction company well connected to the previous regime but with limited experience in building gas pipelines. It apparently used steel pipe that easily corroded.
[8] This assumes 30 million ft3/day (out of 70 million ft3/day) from onshore sources is available for Yangon.

Total electricity from natural gas in Myanmar in 2011 was less than 6 million kWh or only 33% of the amount that could be generated from a modern combined cycle generator using an equal amount of gas. The 2011 gas availability for electricity averaged 113 million ft3 a day, with most of it destined for the Yangon region. The power output from 2011 should increase, as shown, by a factor of more than three with a shift to modern combined cycle generation and could increase even more with higher amounts of natural gas supply to Yangon, already within existing pipeline capacity.

However, after these efficiency and capacity utilization gains are realized, it will be necessary to upgrade the pipelines providing natural gas to the Yangon area. The simplest might be to re-install the Southeast Pipeline now operating at only about 1/3 of its rated capacity. Although pipelines are expensive – the 2011 US price was $100,000 per inch-mile (that is one mile of a 20 inch pipeline would cost $2 million) – a 300 mile upgrade would cost in the neighborhood of $600 million with 20 inch pipe or $720 million with 24 inch pipe. However, this assumes properly coated steel which would resist adverse soils and corrosion from the gas. Since the 24 inch Yetagun pipeline has a capacity of up to 300 Mft3/day, it is likely that a similar pipeline (also gathering gas from Zawtika and perhaps other gas fields) could carry that amount to Yangon as well. This would amount to over 100 million thousand ft3 a year, so the added cost of delivering the gas should be less than $1 per thousand cubic feet.

Conclusions

1. The electricity demand projections are now more reasonable, but may still be low if GDP growth is in the 7-8% a year range suggested by the President. This assumes an electricity to GDP growth ratio of two, typical of ASEAN economies at this stage of development.
2. Much more electricity supply is needed, as well as transmission and distribution upgrades. The currently planned capacity additions are inadequate into 2015.
3. **Action**: Immediate investment in combined cycle gas generators is needed to boost output, lower costs and to get more electricity from a limited gas supply. This is in addition to the single stage gas turbines ordered from GE in December through the Toyo-Thai agreement.
4. **Action**: Upgrading pipelines carrying gas into Yangon is required to increase gas supplies from offshore fields. The most urgent is repairing the Southeast pipeline. Increasing its capacity either by putting in higher compression or bigger pipe will be needed in this decade.
5. **Action**: Raising the price of electricity to industry and heavier residential users to 10-12 cents per kWh is necessary to finance adequate supplies and avoid very costly diesel use. (See Appendix 1 for comments on household electricity pricing.)

Appendix 1: The Cost of a "Lifeline Rate" Keeping 35 kyat/kWh for Low Users

One frequently voiced objection to higher electricity rates is that it would hurt "the poor" – although only one in four households have any access to electricity at all and most of these are not poor. But it perhaps makes sense to maintain a low price of electricity for those who are poor, though most would gladly trade somewhat higher prices for availability and reliability. One simple test is to use a modest amount of electricity use as a measure of poverty. From April 2010-March 2011, the average household used 101 kWh a month or 3.3 kWh a day. If poor households were defined by use of 1 kWh a day or less (enough for lights, a fan, TV and a sewing machine), then how much would the subsidy to the poor cost? Assume a charge of 90 kyat/kWh for unsubsidized electricity delivered to homes.

There were 2.2 million homes with electricity in 2010-11, so let us assume 2.5 million now. If half of all electrified households or 1.25 million were using no more than 365 kWh a year, then a maximum of 456 million kWh would be subsidized. The cost of the subsidy is 55 kyat/kWh or 6.5 cents at current exchange rates. The total maximum cost under these assumptions – half of all households at the minimum and all using exactly 365 kWh a year – would cost $30 million. If **all** currently connected households got a low rate on the first 365 kWh a year, the cost would be up to $60 million. If **all** households (about 9 million) were electrified and got the subsidy on the first kWh of use per day, the subsidy cost would rise to $214 million.

Because the cost of not having electricity far exceeds the cost of power at any reasonable cost, it makes sense to limit the subsidy to the truly needy and use the extra revenue to expand connections. If a household has a certain level of capacity – say more than 10 amps – then one option is that the subsidized rate not be available at all. This would limit the cost of the subsidy to those who are really of modest means. For example, if all nine million households were connected but only five million had a low-capacity connection and on average each one used 300 kWh a year, the subsidy cost would be less than $100 million a year. While not small, this is a level that would not create major distortions. A subsidy based on this approach would start at a modest cost and cap the maximum amount paid. As the nation got richer, the subsidy would shrink since more and more consumers would want more capacity.