International Growth Centre

Energy in Myanmar

Tim Dobermann

March 2016

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Policy Brief

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March 18, 2016

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*Country Economist, Myanmar, International Growth Centre. Email: tim.dobermann@theigc.org

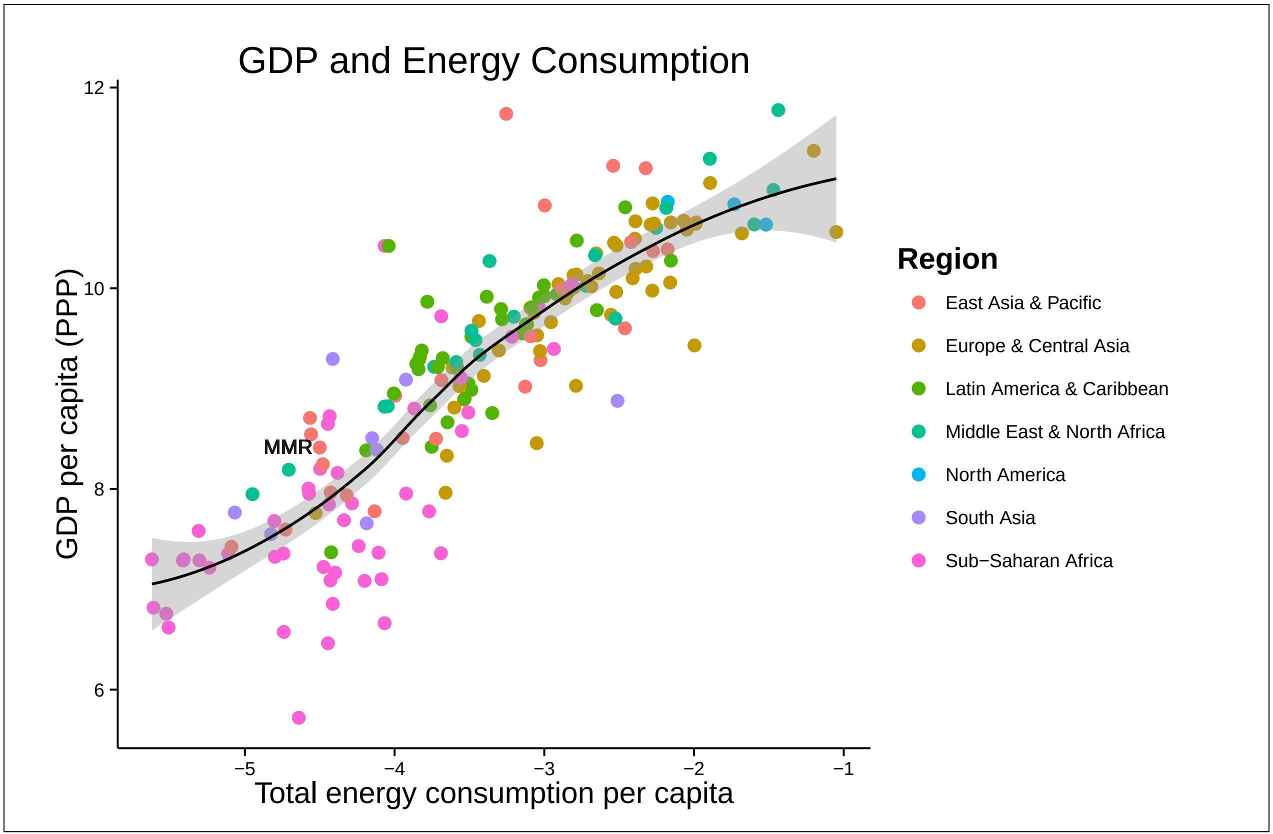

Figure 1: Per capita GDP and **final** energy consumption in natural logs. This allows us to investigate the relationship in proportionate terms. Natural logs look at **growth rates** of income and energy. **Data**: World Development Indicators

1 Introduction

Economic growth requires energy. Energy fuels industry and manufacturing, improves livelihoods, and connects markets. Consuming more energy is part of transforming into a modern economy. The historical relationship is quite clear: over time, economies which grow continue to do so while using more energy.[1]

Comparing per capita income and energy consumption figures across countries today shows a non-linear relationship. Moving away from low, almost non-existent, levels of energy use, there is a sharp uptick in incomes. Once a country is wealthy, the positive relationship between energy use and income seems to level off. Energy, therefore, seems crucial at the early stages of development.

This is highly relevant for the cluster of low-energy, low-income countries found in the bottom-left of **Figure 1**. Most of these countries are in Sub-Saharan Africa. A few are in Asia; Myanmar is one. Economic growth and structural transformation of these countries relies on harnessing energy to power activity, be it in manufacturing, industry, or services. For consumers, electricity not only frees up time, but also enhances human capital and leisure.

Putting all of this in place requires a substantial policy effort. While energy is fundamental, guaranteeing

[1]Making a more definitive claim, such as if a country can increase its energy supply for consumption by x%, then it will grow y% faster, isn't easy. Internal, country-specific factors will influence what effect greater energy consumption will have on economic growth. The time period also matters. Contemporary growth might exhibit even larger returns from electrification as there are more energy-using technologies today which can benefit economic activity. This wasn't the case when modern, advanced economies started their growth spurts in the 18th and 19th centuries, for instance.

access to modern forms is not easy. The varied geography of Myanmar, from the mountainous states of Kachin and Shan to the beaches of Mon and Tanintharyi, complicates this further.[2] Policies supporting the development of off-grid alternatives are important for remote regions. Large-scale grid expansion is necessary but not sufficient for Myanmar's long-term development goals. A separate issue is distinguishing between access and reliability. Demand varies throughout the day. If electricity generation is unable to match these cycles of demand, blackouts occur. Intermittent supply disrupts production, harming productivity and influencing the day-to-day activities of modern cities. Providing quality electricity throughout Myanmar needs policies that put the right incentives in place. Reforming the industrial structure of the energy sector and altering the current tariff schedule can make investments into improved energy infrastructure more attractive financially.

The motivations behind tariff reform aren't only financial. Prices should embody the social costs of energy consumption: pollution and emissions from its use. Without these externalities priced in, expanding renewable energies looks to be a very expensive plan for a developing country like Myanmar. Changing the way energy is priced in Myanmar can help it utilise its wind and solar potential.[3] Pushback to such reforms might argue that raising electricity prices is regressive. Evidence shows that benefits of artificially low prices do not flow to the poorest, but instead to those who are already better off.

This brief looks at each of these issues in hand. The goal is to link international experience in energy policy with the local Myanmar context. Research in these areas have been sparse; the paper ends with a summary of a key research agenda for the country. A final note: this paper focuses on *electricity*. Other important areas under energy, such as petroleum products and fuels for transportation, are not touched on.

[2] These are also the factors which provide Myanmar with tremendous energy potential. From hydropower to solar to natural gas, it has very large reserves. Hydropower potential is estimated to be more than 100,000 MW of installed capacity.

[3] Currently, only hydropower is being exploited commercially. There is known technical potential for windpower in Shan and Chin states and along the coast. Estimated solar potential is tremendous, at 51,973 TWh per year, and is found in the central dry zone.

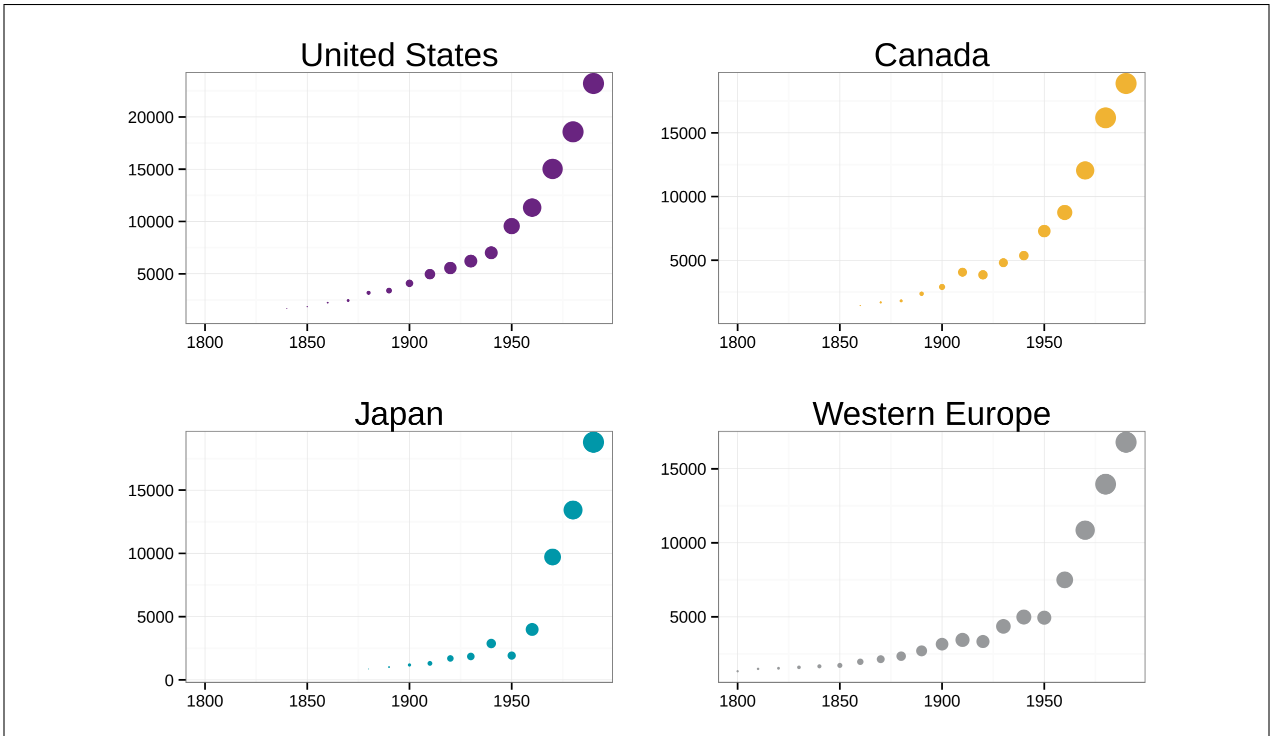

Figure 2: Historical GDP per capita and total energy use statistics for four select countries. The left (y) axis is GDP per capita in 1990 US dollars. The size of the bubble represents total energy consumption.
Data: Maddison Project, History Database of the Global Environment

2 Energy as a source of growth

Energy consumption has been the engine of modern economic growth. **Figure 2** shows the historical relationship between energy and growth for four modern economies. Larger incomes have come with greater energy use. The relationship runs both ways: more wealth means more opportunities to consume energy, while more energy means more opportunities to create wealth (Ozturk 2010). But some facts remain: capital is more energy intensive than labour, and capital is key to economic growth. Energy allowed the adoption of technologies which greatly boosted labour productivity, leading to economic growth (Jorgenson 1984, Lucas 2002, Crafts 2004). The time and cost of transporting goods and people fell substantially. Factories could now produce more, at cheaper rates, and sell to a wider network of consumers. The labour force became empowered, or became free to focus on more productive tasks. With a greater movement of people came a greater exchange of ideas, and innovation followed.

Myanmar, like other developing countries today, can skip the long process of technological innovation that modern industrialised economies went through. It is already 'leap-frogging' outdated technologies and using the latest vintages; the smartphone market in Myanmar is the best example.[4] The challenge is providing fuel for these modern technologies to run on. Consider the telecommunications sector: by 2017, Myanmar anticipates a doubling or tripling of the number of mobile service towers throughout the country to meet demand.[5] Mobile technology can spread economic information (Jensen 2007), reduce transaction

[4]See 'Tech Scene in Myanmar Hinges on Cellphone Grid', *The New York Times*, July 2014. [Link]
[5]The massive expansion in telecomms infrastructure probably falls down to the ultra-competitive nature of this sector. There are three players: a state-owned (but becoming privatized) firm, MPT, and two foreign firms, Qatar's Ooredoo and Norway's Telenor. All are fighting over establishing market share, racing across the country to provide coverage. An estimate is by the

Table 1: Gross electricity production (TWh) in neighbouring countries, 2013

Country	Coal	Oil	Natural Gas	Hydropower	Solar+Wind	**Total**
Bangladesh	1.23	6.69	44.08	0.89	0.15	53.04
Cambodia	0.17	0.58	–	1.02	0.00	1.78
Myanmar	**0.51**	**0.06**	**2.44**	**8.88**	–	**11.89**
Thailand	32.91	1.68	117.06	5.75	1.38	165.71
Vietnam	24.83	2.27	42.65	57.13	0.09	127.03

Data: International Energy Agency – Electricity Statistics (2013)

costs, and help in the set up of essential services, such as credit (Jack & Suri 2014). The benefits of mobile technology rests on having electricity. Mobile towers, especially in hard-to-reach areas of Myanmar, must be kept running to ensure live coverage. Consumers need to find ways to charge their devices. Tackling this infrastructure challenge is part of the transition onto a modern growth path.

Comparative experiences for Myanmar

Myanmar's re-entrance onto the global market makes the issue more pressing. Evolving into a competitive export-oriented economy with greater foreign investment requires modernising and scaling up electricity capacity. Luckily, Myanmar is not without neighbours, and analysing experiences from other Mekong region countries can be informative of how to manage this process.

Table 2: Electricity consumption: 1990 & 2013

	Myanmar		**Vietnam**		**Thailand**	
	Per capita	Total	Per capita	Total	Per capita	Total
1990	40	1,735	100	6,186	710	38,344
2013	160	8,714	1,310	114,100	2,490	164,322
Growth	300%	402%	1210%	1744%	251%	329%

Per capita figures in kWh, total figures in GWh. **Data**: International Energy Agency

Myanmar and Vietnam were both in energy poverty in 1990. However, over the past two decades a large gap in energy consumption has emerged. This striking departure is seen in **Figure 3**. Myanmar has per capita income and electricity consumption levels equal to that of Vietnam around 1995. Vietnam is a nice comparison, as both Vietnam and Myanmar have high hydroelectric potential. Hydropower constituted the majority of electricity consumption for both countries in the early stages of growth (see **Figure 5**). Vietnam's experience is informative for Myanmar's planning. Vietnam had an average growth rate of electricity consumption of 13.5% over the past two decades. Myanmar can expect a similar level of growth going forward. Unfortunately, infrastructure and institutional challenges in Vietnam meant its growth was not very well managed. Initially, a heavy reliance on intermittent hydropower resulted in blackouts. Supply was unreliable. The large presence of a state electricity company, Vietnam Electricity (EVN), eliminated most incentives for private firms to come in and fill gaps in demand. Faced with surging demand, the government embarked on a dramatic expansion in total capacity between 2007 and 2015. Total capacity increased by more than four times the 2006 level. Myanmar is now at the stage Vietnam was a decade or two ago, when

end of 2015 there will be around 6,000 mobile towers. To meet demand, between 17,000 and 25,000 total towers are needed by 2017.

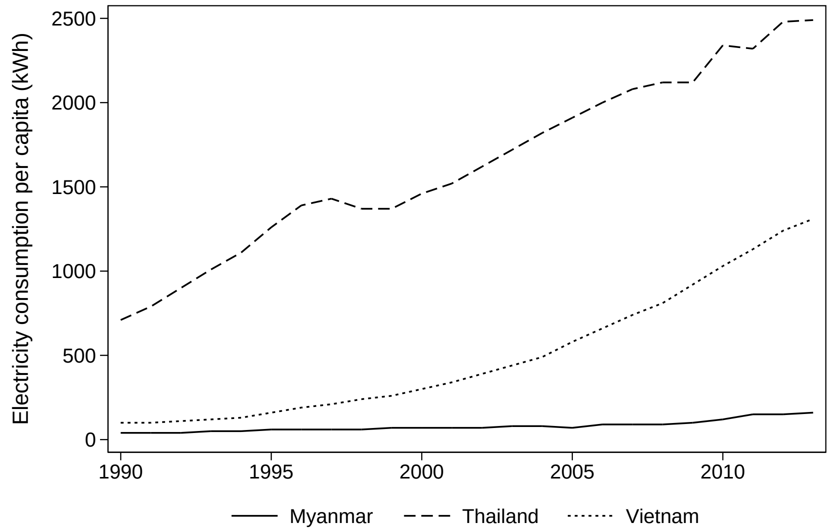

Figure 3: Per capita electricity consumption over time, in kWh. **Data**: International Energy Agency.

it struggled to meet demand and avoid blackouts.[6]

Choosing the right fuel for growth

Comparing Vietnam's actual electricity mix over time versus Myanmar's *planned* electricity mix shows the different approach of the two countries (see **Figure 4**). Remarkably, contemporary Myanmar aligns with 1995 Vietnam on several key statisitcs: income per capita, electricity consumption per capita, and share of hydropower in electricity generation. To ween off its dependence on hydropower, Vietnam made a large investment into gas between 1995 and 2003. Current plans from the Ministry of Electric Power (MOEP) show Myanmar reducing its reliance through greater coal consumption instead.[7]

For the time being, put on hold environmental considerations (**Section 5** discusses this in greater detail). To match swings in the supply and demand for electricity, a base-load fuel such as coal or natural gas is needed.[8] Deciding the share of various fuels in the country's long-term electricity mix is a fundamental planning question. Coal is often abundant and cheap, and might therefore be preferred from a financial perspective. However, bringing a large-scale coal-fired plant into operation may take longer to construct and require higher upfront capital costs. Operation and management costs might also vary depending on the type of plant.

A quick accounting exercise can be undertaken:[9]

[6]Caution should be in order. Vietnam certainly is not an exemplary model for electrification. Many issues continue to plague it, some of which are highlighted for comparative purposes throughout the text. Thailand has been much more successful. Regardless, relative to Myanmar, Vietnam has positive aspects and a similar context.

[7]The yet-adopted Energy Master Plan, prepared for the Ministry of Energy, also sees a significant rise in the share of coal in electricity generation.

[8]Once a coal-fired or gas-fired power plant is up-and-running it can supply electricity continuously with little variation in output. This is what is referred to as a base-load or base fuel.

[9]These figures should be viewed as illustrative and not instructive; final costs will certainly vary tremendously.

Table 3: Example costs of various electricity units

	Fixed cost (cents/kWh)	Build time (years)	Fuel cost (cents/kWh)	Lifespan (years)	Annual run-time (hours)	**Total** (cents/kWh)
Hydro	3.5	3–6	–	40	4,000	3.7
CC Gas	1.2	3	4.7	20	6,000	6.3
Gas turbine	2.6	1–2	6.3	15	2,000	9.6
Coal	2.0	4	2.8	30	6,400	5.6
Diesel	1.6	1	22.5	10	2,000	32.6

Operation and management costs not shown; these vary from 0.2 cents/kWh (hydro) to 1.0 cents/kWh (diesel).
CC gas is combined cycle gas. Fuel prices: \$80 per tonne for coal and \$7 per million BTU for gas, reflecting domestic rates.
It should be noted that current market rates, especially for coal, are considerably lower (coal: ≈\$55–60).

On a least-cost basis, coal is the cheapest option for lowering hydropower reliance, though only by a small margin over a combined-cycle gas power plant. For this reason coal might be appealing, despite its greater environmental and health impacts, compared to natural gas. Government projections for Myanmar see a large rise in coal consumption. Interestingly, one can compare Vietnam's actual shift in electricity mix to the planned mix for Myanmar:

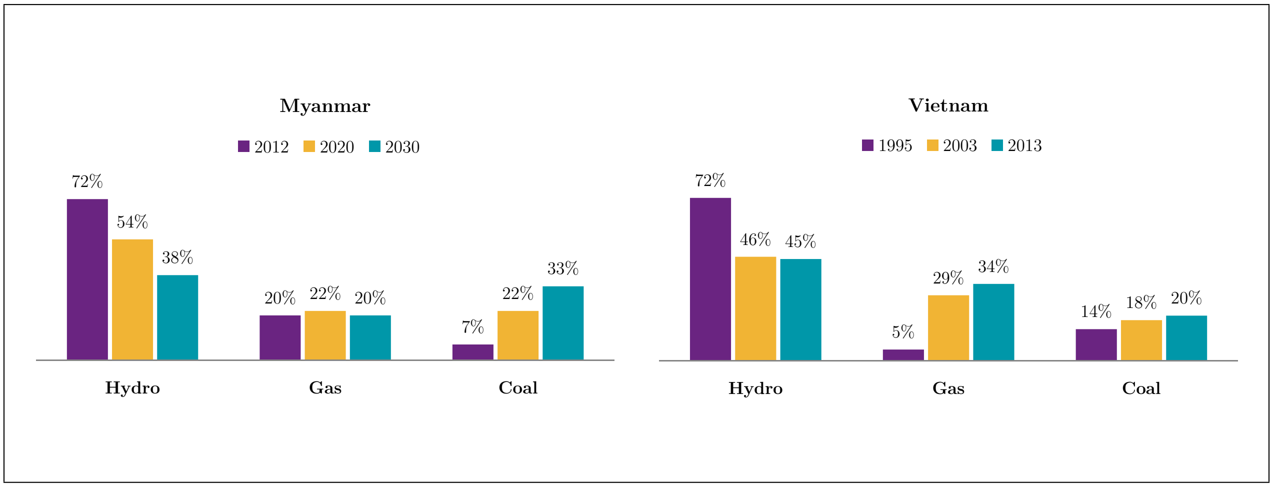

Figure 4: Electricity mix (% generated by each source). Projections for Myanmar from Ministry of Electric Power. Note: recent suggestions in the Myanmar Energy Master Plan deviate slightly: by 2030, hydro will have a larger share (57%), while the gas share falls down to 8%.
Data: MOEP, International Energy Agency.

Vietnam quickly dropped its dependence on hydropower through a large increase in gas. If Myanmar continues as projected, it will do so through greater use of coal. Deciding solely on a cost-basis has pitfalls. Offshore natural gas supply is abundant, while coal found in Myanmar is low quality. For an efficient coal-fired plant, coal would have to be imported from Indonesia or Australia (high calorific bituminous coal). Coal plants are also unpopular because they are dirtier.[10]

[10]See, for example, "Coal power projects to be delayed", *The Myanmar Times*. [Link].

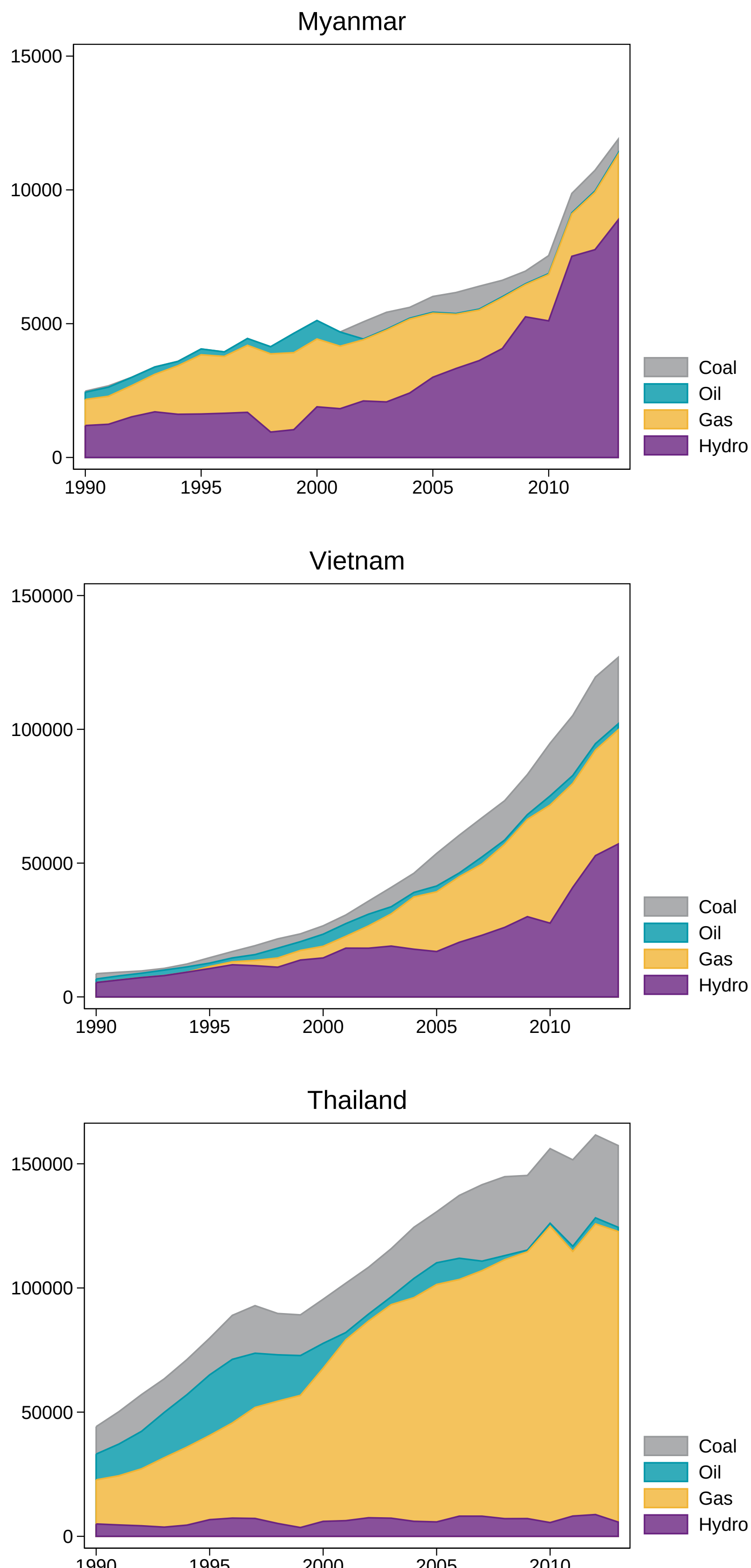

Figure 5: Sources for electricity for select countries. Units are GWh. **Data**: International Energy Agency.

Choosing the country's long-term electricity mix is a primary policy priority, and there are many angles to consider. The arguments for greater coal use reflect the reality that most of Myanmar's natural gas supply is contracted out to Thailand and China. Changing these contracts is very difficult, so more natural gas might not even be an option. Furthermore, new supplies of natural gas are only projected in the next decade.[11] Low commodity prices have dampened incentives for further exploration. Lastly, natural gas also has uses for industry, refineries, and other plants (e.g. fertilizer). Under the Energy Master Plan, the use of natural gas is minimised in the power sector in favour of allocation to industry. As Myanmar industrialises, the demand from industry for natural gas and other fuels will also rise. The end result could be a squeeze in natural gas and energy supply more generally, even to the point where Myanmar may be a **net importer** of energy by 2030.

3 Accessing modern and reliable forms of energy

Access to reliable energy transforms lives and economies. It benefits income generation, enhances specialization, allows more productive capital inputs to substitute for labour, affects the intertemporal allocation of time among households (particularly for women), opens up markets from lower transaction costs, and more (Lipscomb et al. 2013, Dinkleman 2013, Toman & Jemelkova 2003, Jensen 2007). The global reality, however, is one of stark inequality.

Current per capita electricity consumption is very low in Myanmar, around 150–160kWh. As reference, it takes 130kWh to use a standard 60 watt lightbulb for six hours per day for a full year. In contrast, this is about one-fourth of India's per capita electricity consumption ($\approx$ 680kWh), nearly one-tenth of Vietnam's ($\approx$ 1,285kWh), or one-twentieth of China's consumption ($\approx$ 3,300kWh). To take the comparison one step further, one American consumes, on average, as much electricity as 85 Burmese ($\approx$ 13,500kWh).

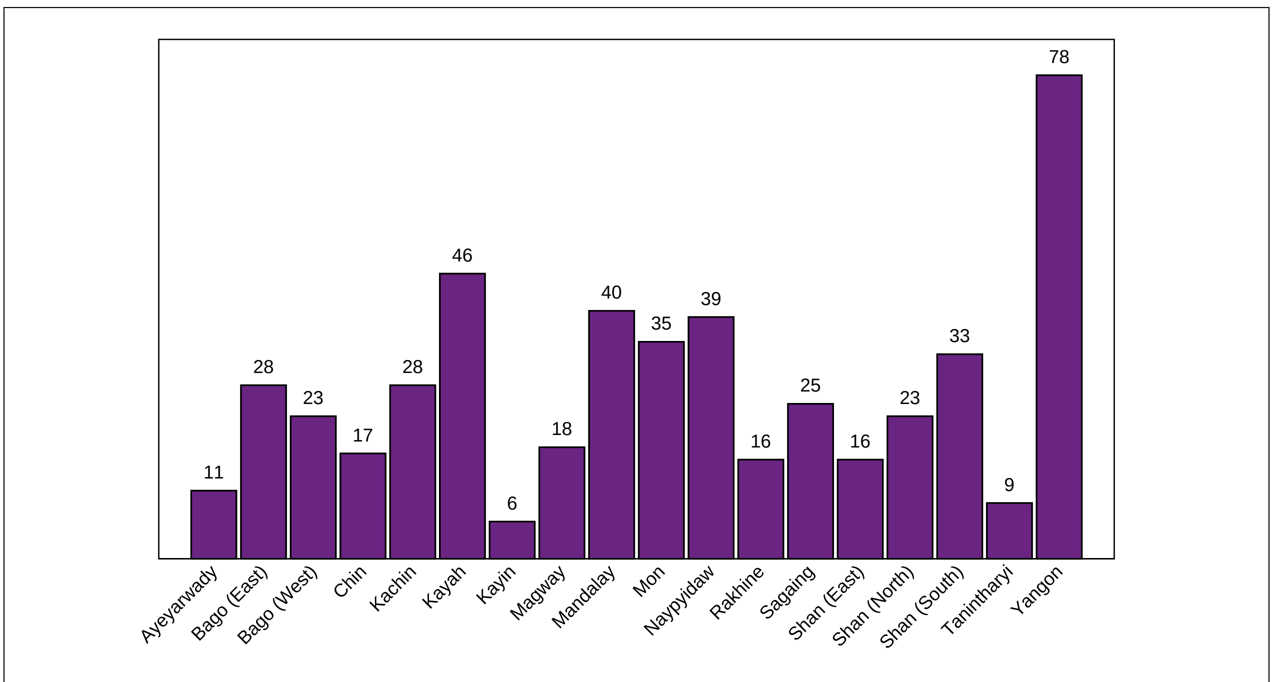

Figure 6: Electrification rate (%) across states and regions, as of late 2013. **Data**: MOEP, ADB

[11] The M3 gas field is one gas field expected to start operation at the end of this decade. However, this will mostly offset already *decreasing* supply as existing fields like Yadana see their output decline.

This low per capita figure masks a large internal issue: inequality *within* the country in access to electricity (**Figure 6**). The country-wide electrification rate is 31%, but there is substantial variation: Yangon has an electrification rate of almost 80%, while the rural average is as low as 16% (ADB 2012, Nam et al. 2015). Rural villages cannot tap into a steady stream of electricity, such as the grid. However, alternatives such as diesel generators are quite common, despite their high costs (KWR International 2015). The use of small solar devices is also growing. Burning biomass remains the dominant form of energy, mostly in cooking or heating. Rural communities therefore do not entirely lack energy, but they do lack modern forms. Providing **modern** forms of energy which are cheaper, always available, reliable, and more efficient is the challenge. Electrification is not a guarantee of economic growth or povery eradication, but in conjunction with other sectors, it enables pro-poor growth.

To address these challenges, the government of Myanmar has embarked on a plan for country-wide access to electricity by 2030. The **National Electrification Plan (NEP)** is formed of grid and off-grid components. 7.2m households are to be connected to the national grid, while support for remote communities in adopting off-grid technologies such as solar or micro/mini-hydropower will be given. There are currently 200,000 residential customers to the power grid. By 2020, the NEP targets 500,000 new connections each year (World Bank 2016).

Building Myanmar's national grid

Expanding the national grid is a long and arduous process, but it has its merits. Despite the tremendous investment, it is the most cost-effective means of electrifying the entire population. On paper, once a grid has been established and connections have been made, consumers have access to electricity around the clock. This access is also unconstrained in a material sense, as the onus of providing fuel shifts to power plants (and not on the individual tasked with re-fueling a diesel generator, for instance). As long as the tariff gets paid, consumption can continue. The grid supports higher voltages, which can be more efficient for supplying firms or industry. Benefits also stem from opening up new opportunities for economic activity. A small local enterprise which requires a threshold level of electricity use might not be financially viable if it requires upfront capital costs for generation (generators, or an alternative like solar), but might become feasible under grid connection.[12]

The topography of the land determines the cost of expanding the national grid. Building the grid in mountainous areas is more expensive. For a country with such varied geography, this implies that some areas of Myanmar are not suited for grid electricity. A prominent feature of the NEP is that the grid is planned on a spatial least-cost basis.[13] Areas closer to existing lines and in flatter terrain are to receive the grid sooner. Mountainous and remote regions can expect the grid to arrive much nearer to 2030, if at all. A priority, instead of waiting, is to help develop local grids in these regions which can later be connected to the main line when it arrives (referred to as 'pre-grid electrification').

The total cost of the grid expansion, including investments into generation, transmission and distribution, is around $10 billion over the next decade and a half.[14] Financing these investments requires a financially viable power sector. It is currently not viable: tariffs are below costs of production. Amending tariff policy is key for meeting expected demand; **Section 4** discusses this in more detail.

[12] There are certainly nuances to this argument, which are touched on in the following paragraphs. In the Myanmar context, grid connection is not free, and therefore also poses an upfront financial challenge for potential users.

[13] See Earth Institute (2014) The academic relevance is that the grid will move forward based on **non-political** factors, removing potential selection bias.

[14] According to demand estimates, a further $20 billion of investments into power generation will be needed (World Bank 2016). This assumes steady GDP growth of around 7%.

Connecting to the grid

Once the main lines are constructed, additional connections must be built to link villages and households. The NEP relies on a **self-reliant electrification approach**. The grid will be built to the *township* level. Villages within the township must then organise and *collectively* finance the final stage of connection. Village Electrification Committees (VECs) are formed by the locals themselves, with little guidance, technical support, or regulation. This body then works with local township electricity officials to devise a connection plan, and crucially, to raise the funds from **collective household savings**.[15] Financial support is very limited, and in fact discouraged.[16] However, field studies have shown instances of loans being provided in the past for connection (KWR International 2015).

The nature of this approach raises some immediate concerns. Previous grid expansions saw the cost of a village connecting to the grid being between \$30,000–50,000, or an average of around \$250 per household for those close to the grid (Rabin & Madden 2015). This is substantial: it is more than double the average monthly income. Neighbouring countries like Lao PDR and Cambodia only saw 60% connection rates under connection charges of \$80 (World Bank 2015). Poorer households in a village, which might not be able to make a full contribution, are likely to be left out. A management and organisation problem is also present. Relying on self-formed groups to undertake a multi-year task involving large sums of money could disadvantage the poorest villages. Villages which lack sufficient human capital or organisation capability would therefore be unsuccessful in obtaining a grid connection. Determing how best to support households' efforts to connect to the grid is a key policy research question.

Supplying the grid

Establishing a connection is only the first step. Value comes from a reliable stream of electricity. When the supply of electricity is insufficient, 'load shedding' across the grid must occur (rolling blackouts across parts of the system). These electricity shortages disrupt firm productivity, distort the inputs used for production (a re-optimisation into otherwise inefficient inputs, like diesel generators), and harm growth (Allcott et al. forthcoming, Fisher-Vanden et al. 2015). Regular electricity also benefits rural areas. Diesel generators are widely used despite their high costs because they are reliable. For example, generators often power water pumps. Irregular electricity supply influences the ability to irrigate fields, harming yields. In this case, the willingness to pay for a *constant* source of electricity is high, and generators are adopted.

For countries like Myanmar and Vietnam, blackouts become more pronounced during the dry season when hydroelectric potential falls.[17] A possible solution is to install backup thermal power (electricity generated from burning coal or gas). The Vietnam experience highlights institutional issues: Vietnam Electricity (EVN), the state-owned electricial company, prefered hydropower when available as it comes at near-zero marginal cost. Private investors found it very difficult to strike agreements with EVN on buying thermal power; the right incentives were not in place. For Myanmar, balancing public and private activity in the electricity sector will be key for providing cheap and reliable energy. The current state-owned control of the sector – independent power producers (IPPs) are few, and state enterprises control most distribution and transmisson – makes this an area open for reform (addressed more in **Section 6**).

There are two perspectives from which to approach solving the blackout problem: the demand side and

[15] The emphasis on drawing finance from collective savings, instead of from loans or other financial mechanisms, probably comes from culture. A large part of Myanmar Buddhist culture centres on the importance of community, charity, and cooperation.

[16] The Ministry of Electric Power (MOEP) has a set of '24 conditions' which outline this self-reliant approach. One of them explicity discourages loans. See KWR International (2015).

[17] Larger reservoir capacity can reduce the drop in supply during the dry season. This, however, comes with extra challenges concerning infrastructure and the surrounding environment.

the supply side, although both go hand-in-hand. Understanding how electricity demand evolves and grows over time helps plan investments for the future. Forecasting demand is difficult, especially in a developing country like Myanmar. Factors such as income and credit availability influence when households acquire energy-using assets in a non-linear way (Gertler et al. forthcoming).[18] The long lead times in infrastructure investments – a new power plant takes years to build – implies a good demand forecast can greatly reduce shortages in the future.

Demand forecasts guide a plan of action. Increasing installed capacity and upgrading transmission and distribution infrastructure executes this plan by raising supplied electricity. Current installed capacity in Myanmar is around 4,000MW, with peak load around 2,200MW.[19] The discussion in the previous section can guide policies on which sources are most suitable for ramping up power generation.

Table 4: Government electricity demand projections (MW)

Scenario	2015	2020	2025	2030
Low	2,376	3,862	5,930	9,100
High	2,527	4,531	8,121	14,542

Source: MOEP

An overhaul of existing infrastructure is underway, but it still remains an area for further investment. Some estimates suggest that one half of all existing transmission lines are over 70 years old (Rabin & Madden 2015). Greater generation of electricity will be needed, though there are immediate opportunities to increase supply by reducing electricity lost during transmission and distribution. In Myanmar, 27% of generated electricity is lost along the way, a high figure compared to its ASEAN neighbours (**Figure 7**).

[18] The growth in electricity demand does not share a linear or one-to-one relationship with the growth in income. The same proportionate increase in income can have very different implications for growth in electricity demand depending on the base income level. For example, a poor household which experiences a rise in income, while still remaining relatively poor, is unlikely to see the same rise in demand for electricity as a borderline middle-class household with the same proportionate rise. See Gertler et al. (forthcoming).

[19] Installed capacity refers to the total amount of electricity which could be generated if all facilities operate at full capacity or efficiency. Only a percentage of total installed capacity is actually available at a given point in time, either because some capacity is not operating (repairs or maintenance) or factors such as weak river flow imply less than maximal generation.

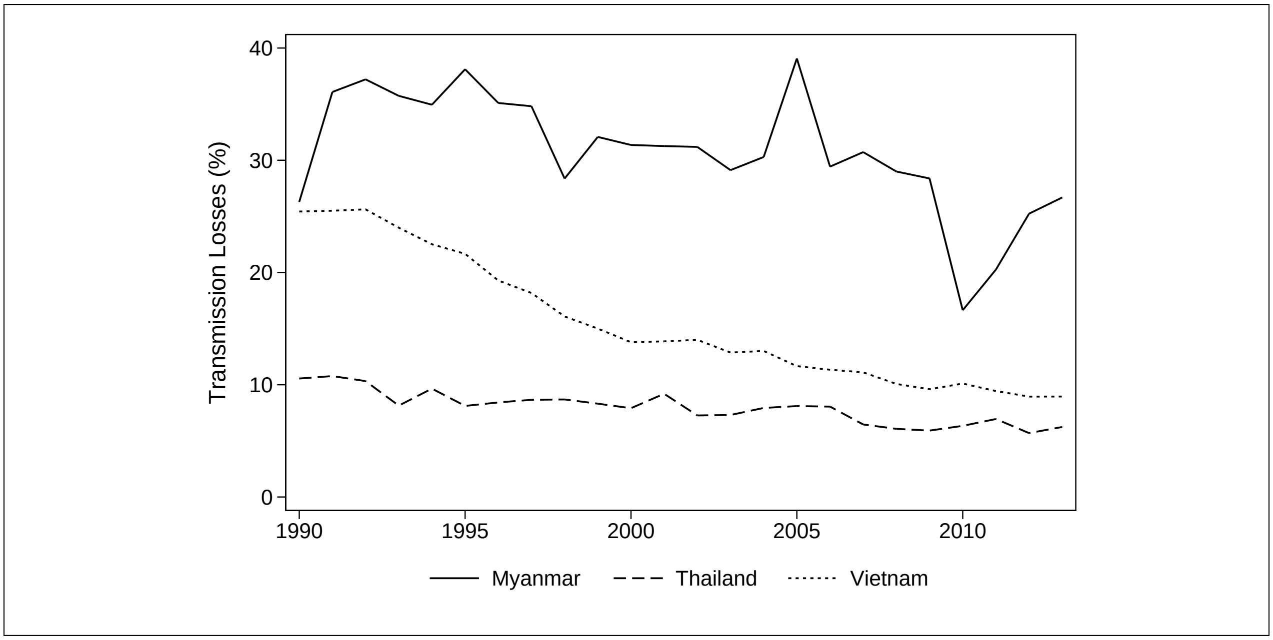

Figure 7: Transmission losses: the amount of electricity lost in the process of moving generated electricity to consumers. **Data**: International Energy Agency.

Many of these losses are likely to come from delapidated infrastructure, though electricity theft could certainly contribute to this high figure.

Moving beyond the grid

Grid electricity will not solve all problems. It is a technically efficient solution for many areas, but not for all. The process of expansion and connection also takes many years (once the grid reaches a township, it can take anywhere between one to four years for households to complete their connections). There exist immediate opportunities for electrifying villages without relying on or waiting for the grid. Two promising technologies to achieve this are solar power and micro hydropower. Currently, largely as a result of charitable or non-governmental efforts, there has been an emergence of small solar devices used for basic lighting and charging of mobile phones. Another technology being used are diesel generators, with individuals in a village paying a fee to access its electricity. **Section 5** looks at these in closer detail.

4 Pricing energy correctly

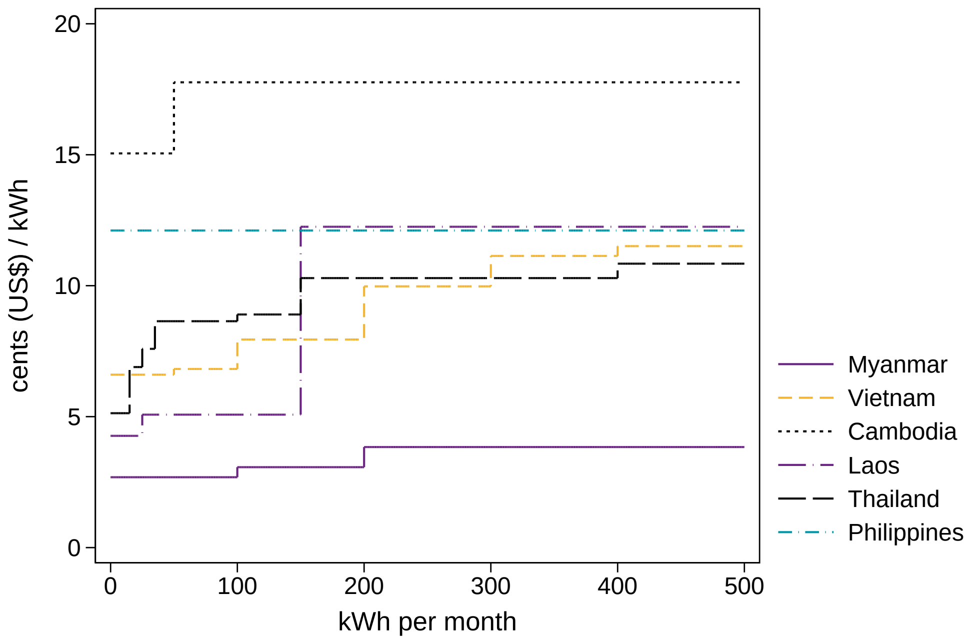

Figure 8: Residential grid electricity tariff structures for various countries. **Data**: Respective government agencies.

Electricity comes relatively cheap for those who can access it in Myanmar. The benefits of electrification hinge on it being affordable. However, finding the right price is not straightforward. An examination of the electricity tariff structure across various ASEAN countries reveals that Myanmar has some of the lowest rates in the region (**Figure 8**). Per kilowatt-hour, the average cost in Myanmar is 2.8 cents (US$), compared to an ASEAN average of around 11.3 cents per kWh.[20] There has been a recent change in 2014, but public sentiment remains quite opposed to rate increases. Depreciation of the kyat makes electricity supply from natural gas more expensive, as prices are denominated in US dollars.

Determing the correct electricity price or tariff is a key policy objective. First, the facts: the existing rates are not financially sustainable over the long term. Recent reforms have allowed private (and international) companies to assist in the generation of electricity. However, all electricity is still sold to the state-economic enterprises, which then transmit and distribute the electricity to consumers at established rates. The revenues from sales of electricity must *at least* offset the costs. This is currently not the case: for each unit of electricity sold to consumers, the government is making a loss. The result is considerable debt: budget figures for MOEP reveal around a $300m deficit in the recent fiscal year.

An argument justifying these losses is that cheap electricity has a wider social impact: helping the poorest. Increasing prices would then only come at the expense of those already worse-off. Economic literature has investigated the effect of subsidies, and most findings suggest this may not be the case beyond lifeline rates. Often, the biggest beneficiaries of low electricity prices are not the poorest segments of society but those who already doing quite well (middle class and above). A pressing policy question is therefore how Myanmar can

[20] Current exchange rates used (late 2015). The on-going depreciation of many countries' currencies in the region certainly influences the figures presented. The average is not strictly an ASEAN average, but rather the average of the other countries in Figure 8 plus Brunei and Malaysia.

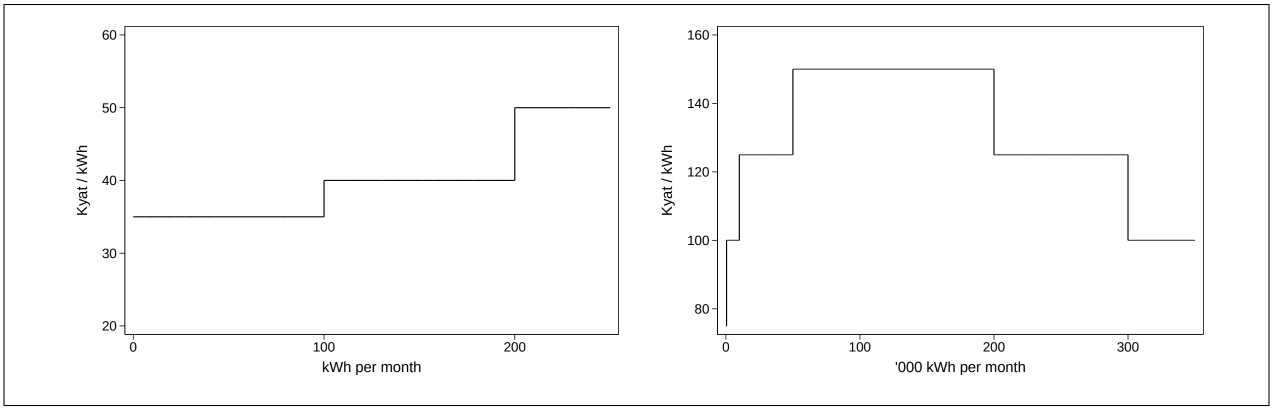

Figure 9: Electricity tariffs for residential (*left*) and industry (*right*) consumers in Myanmar. **Data**: MOEP

raise its tariff rates or adjust its current structure.

The rationale for raising electricity prices goes beyond simply having them reflect the costs of generation. The presence of a very low price twists the incentives for investing into upgrading infrastructure quality, with the direct consequence of suppresing the quality of supply (McRae 2015). Artificially-low prices are harmful. This has greater relevance for the private sector as the incentives for investment are different, but if trends of corporatization and greater private involvement continue, it will be an issue to consider.

Amending the current electricity tariff structure

Setting the price of electricity requires considering how costs will evolve over time. Hydroelectric power is by far the cheapest source for Myanmar, but as the government begins to incorporate more thermal power (coal, gas) into the mix, the average cost will rise. At the very least, tariffs should match this increase. There are several options for Myanmar to increase its tariffs. First, to make rate increases more palatable for the public, they can be gradually increased over time. A transparent rule for increasing tariffs – for instance, a certain percentage increase each year – is useful for both residential and industry or commercial consumers. Deciding prices by a transparent rule can help build confidence in the government.

Second, Myanmar can experiment with adding extra levels or selectively altering some levels and not others. A lifeline subsidy of low rates for the smallest residential users (<100kWh) can be kept while rates for larger users can be increased, or a further jump in price after 200kWh per month could be added. Industrial tariffs, which are higher, are priced closer to actual cost of production, but their structure disincentivises energy efficiency or energy savings. Understandably, the rationale is to attract industrial investment by offering low rates for larger plants. With existing challenges in meeting supply, changing tariffs to encourage efficient use of energy is a good option.

Third, instead of adjusting rates directly, the government can discriminate based on what times during the day energy is consumed. Several countries in ASEAN, such as Thailand and the Philippines, have varying time-of-day tariffs which charge more for electricity consumed during peak hours. Electricity consumed early in the morning or later in the evening could be priced lower than other periods. This adds a price incentive to lower use, or to spread use around time, helping supply match demand and reduce the prevalence of shortages.

Factoring in environmental costs

Thermal power generates electricity by burning fossil fuels. These fossil fuels emit greenhouse gases and other particles into the air which adversely affect the climate and surrounding environment. Other forms of energy, like petrol or diesel for cars, emit particulate matter and nitrogen dioxide which are a cause of urban mortality (Pope et al. 2002). In line with international trends, these external costs should begin to be reflected in the cost of consumption. Pollution will become a growing concern as the urban centres of Myanmar develop; the experiences of China and Indian are examples of this. Factoring in environmental costs would therefore promote investments into public transportation and cleaner vehicles which consume less fuel and pollute far less. These are long-term policy objectives, but deserve adequate representation in the planning process.

5 Moving toward cleaner energy

Myanmar's priority is electrifying its population, and above all, fighting poverty. In the short term, the pressing need to provide electricity access to all might supersede the long-run goal of harnessing energy from clean sources like solar or wind. On average, renewable sources of electricity are likely to be more expensive compared to coal or gas-fired power plants. This, however, is not necessarily true on a case-by-case basis for Myanmar.

Myanmar's renewable potential

Myanmar has tremendous potential to develop renewable energy beyond hydropower. Its central dry zone has an estimated potential of around 52,000 terawatt-hours per year. In Shan and Chin states wind power is viable, with a potential of roughly 4,000MW. Once built, such systems provide electricity at near-zero marginal costs. To encourage their developments, a series of feed-in tariffs can be considered. Feed-in tariffs guarantee a set minimum price for renewable electricity producers, and therefore incentivise investment by increasing expected revenue.[21] The financial case for adopting more renewable technologies grows when we factor in the externalities of burning fossil fuels like coal and natural gas (see **Section 4**).

Solar and wind technologies are attractive options for small-scale provision of electricity, particularly in remote areas. Power plants, whether they burn coal or gas, are very large projects, and require extensive construction of transmission and distribution infrastructure to reach households. This is not the case for smaller solar, wind, or micro-hydro installations. As local solutions for electrification, they are top contenders. Initiatives in the Monywa region of Sagaing, which has high sun intensity, offer a good illustrative example.[22] Here, local and regional governments subsidise access to solar power: half of the $70 cost for solar panel and converter are covered, which are then distributed to villages. Once established, villages organise community sharing programmes. This is an example of a small-scale system which meets the basic electricity needs (2–4 hours a day of lighting, perhaps entertainment in evenings) at a low cost of around 2000 kyat per month for a household. As these areas grow, the amount of electricity demanded will grow, and larger systems will be needed. As a first step towards electrification, however, this presents a substantial improvement over diesel generators.

Confronting the challenges

The fundamental challenge for renewable energy is its intermittency. In dry periods, rivers do not flow as strongly. Solar generates most power during the day when the sun is strongest, but this does not overlap when demand is highest (early evening). Wind speeds fluctuate. Energy from those sources can be stored,

[21] This guaranteed minimum price is not charged directly to the consumer. The consumer still receives the normal retail price, but the government props up the price to this minimum level. It acts as a form of subsidy to help adoption.

[22] Based on field research by KWR International (2015).

though the procedures are complex and the conditions are limited.[23] These are contemporary problems that developed countries are grappling with.

Only once Myanmar has developed enough to invest in widespread storage and advanced or 'smart' grid technology can it rely on renewables for a **dominant** share of its electricity supply *without* threatening reliability. This does not mean all investments into renewables need to be foregone. As highlighted, small solar or hydro systems can be ideal for certain settings in Myanmar. Taking steps towards alowing independent power producers to sell back to the grid any excess supply would be helpful. Such systems are in place in developed countries, but for technical reasons have not achieved traction in Myanmar.

6 Governance and the private sector

The structure of the power sector can influence everything from retail prices to the supply of electricity. The vast majority of generation, transmission, and distribution remains state-led, but recent changes in legislation, such as the new Electricity Law in 2014, now encourage greater private sector participation. Currently over 200MW of private sector power plants have been operational, but MOUs with over 50 companies are oustanding on hydro and thermal power plants (Nam et al. 2015). This represents only a small share, but the future trend is clear.

Until recently, eight ministries were responsible for energy matters. As of March 2016, the new administration has combined existing ministries to create the Ministry of Electric Power and Energy (MOEPE) to streamline government activity in this sector. The National Energy Management Committee (NEMC) devises energy policies in coordination with these ministries. On the ground, various state-economic enterprises carry out most of the work. The Myanmar Electric Power Enterprise (MEPE) develops the national transmission networks and substations. The Electricity Supply Enterprise (ESE) supplies power to the rest of the country, minus Yangon. Electricity distribution in Yangon now falls under the auspice of the Yangon Electricity Supply Corporation (YESC). This stems from a recent change to what was earlier the state-owned Yangon Electricity Supply Board (YESB). Previously under MOEP, YESC is now financially independent.[24] Independent power producers (IPPs) are allowed, and examples of public-private partnerships (PPPs) in electricity generation are becoming more common. Foreign investment still requires links with either a local company or directly with the government.

The Myingyan 230MW combined-cycle gas-fired power plant is a successful model for future PPPs. The contract was awarded through a competitive tender process. To counter concerns over repayment, a multilateral (in this case, the World Bank) provided a partial risk guarantee to ensure payment for the private party.[25] The result was a competitive cost of production: $5.5 cents per kWh.

How the power sector's structure affects the supply, price, and quality of electricity is hard to measure. Myanmar is slowly departing from a single-owned, vertically integrated approach to the sector. International experience suggests this is a positive development (Joskow 2008). Competitive wholesale markets for power create incentives for keeping construction and operating costs low. Myanmar is still very much a single-player market. Being a single actor makes innovation and investments into quality less urgent. If there are mistakes or delays in the construction of new generating capacity or infrastructure, the consumer suffers as there exist no other alternatives. This would not be the case if there were multiple players: high costs or frequent delays

[23] An example is pumped storage. Electricity generated from solar or wind can be used to pump water up to a certain elevation. Once it has reached the top, it can flow down and generate hydroelectric power on demand. However, the conditions under which this is a feasible means to store power are quite limited and cannot be replicated everywhere. It is also expensive. Battery storage is the other alternative, though such technology is not yet suitable in a developing country context.

[24] The same has happened in Mandalay, with the Mandalay Electricity Supply Board (MESB) being transformed into the Mandalay Electric Corporation (MEC).

[25] Under the terms for the Myingyan PPP, the successful developer enters into a power purchase agreement with MEPE. Gas is supplied for free by the Myanmar Oil and Gas Enterprise (MOGE), a state enterprise.

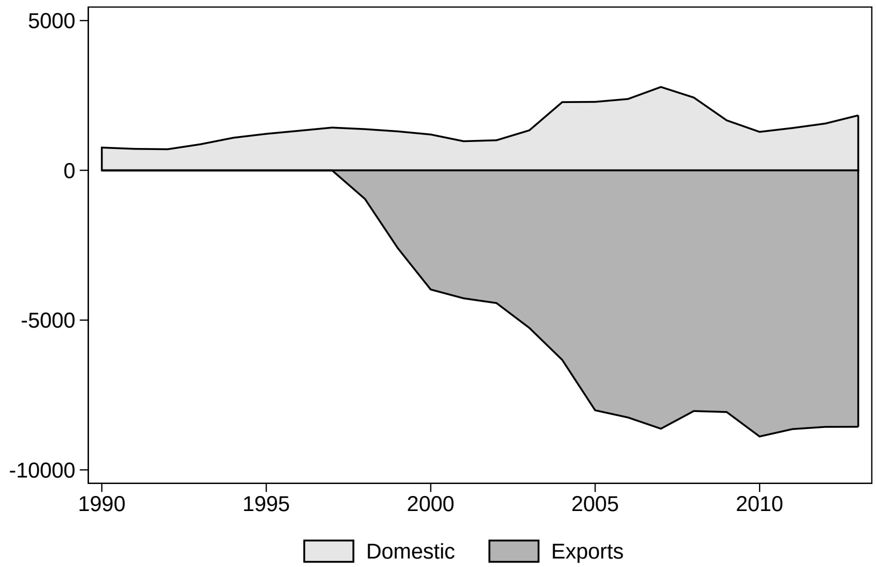

Figure 10: Natural gas exports and for domestic use (ktoe) **Data**: International Energy Agency.

impact the specific firm, but would not affect the user. If one firm fails, another competing firm steps in. Similar arguments apply to privatising transmission and distribution networks: costs are pushed down and improving quality is attractive in a competitive environment.

The experience of electricity market liberalization in England and Wales is a good example of a successful policy (Newbery 2006). To replace a state-owned generating company, new companies were added. Transmissions investments helped the wholesale market become more competitive. Quality and price improved as a result. Chile experienced similar efficiency improvements from its restructuring (Raineri 2006). In India, electricity shortages persisted despite increases in generation capacity because of various constraints, such as distorted retail prices or limits on wholesale trade (Ryan 2014). These examples show how industrial structure can have real effects on the supply of power. For Myanmar, it is a top area for planning and research.

7 Next steps for Myanmar: Building a research agenda

Research is necessary to design effective policies, as solutions are not often obvious. Existing research in Myanmar often focuses on mapping potential hydrocarbon reserves. The series of issues highlighted in this brief – accessing electricity, pricing electricity, making it cleaner, and structuring the market – are all areas where research is needed. However, such an agenda varies between short-term priorities and longer-term objectives.

Immediate policy priorities, areas requiring action within the **next three years**, focus on providing affordable and reliable electricity to all. If good policies are put into place in these areas, they will have a positive impact right away.

Short to medium term priorities:

- As the grid expands, what policies will support villages in establishing connections? Are poorer villages at risk of not being able to finance the connection costs?

- How can tariffs be reformed to improve the financial health of existing utilities and state enterprises? What is the right price given social, economic, and environmental objectives?
- What are the best options for increasing installed generation capacity in a short time? Should border trading of electricity play a role?
- How can losses from transmission and distribution of electricity be reduced?
- What financial incentives can the government provide for the adoption of off-grid technologies, like small-scale hydro and solar?

Policy changes over the **next five to ten years** decide the path the energy sector will take as it matures. They are fundamental for the long-term sustainability of the sector.

Long term priorities:

- What electricity mix (coal, gas, hydro, other renewables) should the government strive for? Which options are cost-effective and least harmful?
- Following the recent corporatization of YESC and MEC, what institutional structure is best for the country? Can these policies encourage more FDI into the sector? What would a wholesale market for electricity in Myanmar look like?
- To match expected growth and urbanisation, where should new transmission lines be built, and how can existing ones be upgraded?
- How much energy and/or electricity should be kept for domestic use, and how much should be exported? Can existing export contracts be re-negotiated to draw in more supply for domestic use?
- How can the government assist in large-scale renewable electricity generation, and which technologies require more research and development to be efficient?

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