UNITED NATIONS
UNIVERSITY
UNU-WIDER

WIDER Working Paper 2021/62

An economy-wide perspective on aspects of electricity supply in Myanmar

Dirk van Seventer*

April 2021

United Nations University World Institute for Development Economics Research

wider.unu.edu

Abstract: Myanmar's economy has experienced political and economic transformations since 2011 by means of diverse economic reforms. However, the power sector is still struggling to fulfil electricity demand. This study will examine aspects of the electricity sector in an economy-wide perspective by means of multiplier analysis based on a recent Social Accounting Matrix for Myanmar. The paper begins by providing a brief scene-setting context for the electricity sector in Myanmar and discusses its developmental issues in the last decade or so, since the start of the recent political and economic liberalization. Some of these issues will be the subject of a multiplier modelling effort. The modelling shows that insufficient and infrequent supply of electricity can have far-reaching consequences, some of which are not obvious at first. This highlights the importance of understanding the network of inter-industry interactions even in an economy of which the different elements are not as interconnected as in many other countries.

Key words: economy-wide perspective, Social Accounting Matrix, multiplier analysis, electricity sector, Myanmar

JEL classification: E16, O1, O2, O53

Acknowledgements: This research is part of the 'Towards inclusive development in Myanmar' project, supported by Danida and implemented in collaboration between UNU-WIDER, the Central Statistical Organization (CSO) of the Myanmar Ministry of Planning, Finance and Industry (MoPFI), and the Development Economics Research Group (DERG) of the University of Copenhagen.

* Consultant, UNU-WIDER; denvanseventer@gmail.com

This study has been prepared within the UNU-WIDER project Towards inclusive development in Myanmar.

Information and requests: publications@wider.unu.edu

ISSN 1798-7237 ISBN 978-92-9267-000-9

https://doi.org/10.35188/UNU-WIDER/2021/000-9

Typescript prepared by Luke Finley.

United Nations University World Institute for Development Economics Research provides economic analysis and policy advice with the aim of promoting sustainable and equitable development. The Institute began operations in 1985 in Helsinki, Finland, as the first research and training centre of the United Nations University. Today it is a unique blend of think tank, research institute, and UN agency—providing a range of services from policy advice to governments as well as freely available original research.

The Institute is funded through income from an endowment fund with additional contributions to its work programme from Finland, Sweden, and the United Kingdom as well as earmarked contributions for specific projects from a variety of donors.

Katajanokanlaituri 6 B, 00160 Helsinki, Finland

1 Introduction

Reform in the electricity sector is part of the diverse economic policy measures initiated during the post-2011 period in Myanmar. Urbanization, greater use of electrical devices, and growth in the processing and manufacturing sectors has raised the demand for electricity over the past decade. From the supply side, the government of Myanmar is enhancing production and distribution of electric power from diverse sources, both renewable and non-renewable. Myanmar achieved 50 per cent nationwide electrification in December 2019 and its target is to reach 100 per cent by 2030–31. In order to realize this electrification plan, the Ministry of Electricity and Energy (MOEE) also aims to raise electricity tariffs in order to fund the build programme and roll-out. At the same time, customers demand uninterrupted electricity supply. The electricity price hike in 2019 has had impacts on both households and businesses. As will be shown later, the new electricity tariffs represent a significantly increased expense for households and, albeit to a lesser degree, also for businesses, compared with the previous tariffs.

Myanmar's economy has experienced political and economic transformations since 2011 by means of diverse economic reforms. However, currently the power sector is still trying to fulfil electricity demand. The need for an adequate and uninterrupted supply of electricity at reasonable price can be regarded as one of the factors crucial to the future wellbeing of the economy. This study will examine aspects of the electricity sector in an economy-wide perspective by means of multiplier analysis based on a recent Social Accounting Matrix for Myanmar (van Seventer et al. 2020a, 2020b).

The paper begins in the next section by providing a brief scene-setting context for the electricity sector in Myanmar and discusses its developmental issues of the last decade or so, since the start of the recent political and economic liberalization. Some of these issues will be the subject of a multiplier modelling effort; the methodologies thereof will be discussed in Section 3. The results are presented in Section 4. Conclusions and some policy perspectives end this report.

2 Context[1]

Several studies have discussed the importance of electricity as a contributor to economic development. Stern et al. (2016) and Bee (2016) show positive relationships between access to reliable electricity and its utilization and economic development in developing economies. Access to electricity has a positive effect on productivity, profitability, education, health, safe water, information, and communication (Attigah and Mayer-Tasch 2013). It plays a vital role, from everyday routines at the individual and household levels, to production and trade of goods and services at the economy-wide level.

However, some developing countries still face shortages of electricity that can affect their economies in a negative way, directly and indirectly. In particular, power shortages generate economically undesirable impacts on the production and profitability of large firms, small and medium enterprises (SMEs), market access, and attractiveness and competitiveness in local and international markets.

[1] This section draws heavily on Khine Nyein (2020).

For developing countries like Myanmar in particular, there are challenges in balancing electricity demand and supply in the context of an emerging industrial sector. Myanmar is still facing power shortages which generate negative effects on its households and business sector in diverse ways.

2.1 Supply of electricity

In the post-2011 period, the National Energy Management Committee (NEMC) and the Energy Development Committee (EDC) have played a leading role in implementing priority functions to ensure the development of the energy sector and the electric power subsector. In 2013, the National Electricity Master Plan (NEMP) was prepared with the support of the Japanese International Cooperation Agency (JICA), which targeted 50 per cent of households to be electrified by 2020, 75 per cent by 2025, and 100 per cent by 2030; 99 per cent are envisaged to be electrified by national grid and the rest are to be provided for by off-grid supply. The government continues to reform and extend the energy infrastructure to support the country's sustainable economic growth. The National Energy Policy was successfully adopted in 2015 after co-operation with major stakeholders (see ADB, IES, and MMIC 2015).

The most recent institutional reform in the energy and electricity sector was carried out in 2016 with the establishment of the MOEE. In order to achieve the goal of 'all-inclusive sustainable development', the Ministry of Electric Power (MOEP) and Ministry of Energy (MOE) were merged into MOEE.

According to the policies set by the MOEE, electricity generation from hydropower is regarded as a main player in the long-term plan and gas-fired power generation is a key to achieving short-term goals (MOEE 2020a).

Myanmar has been regarded as a country endowed with rich energy resources. The country has abundant hydropower reserves, which is useful for producing low-cost electricity. Moreover, Myanmar possesses large offshore oil and gas reserves. As stated by the Asian Development Bank (ADB 2012: 4), the hydropower potential in Myanmar is estimated to be more than 100,000 megawatts (MW, or 100 gigawatts). Ninety-two potential large hydropower projects have been identified for future consideration, with a potential total installed capacity of 46,101 MW.

Table 1 reports the diverse sources of energy in Myanmar in 2019. Among these energy resources, around 60 per cent of all electricity is generated by hydropower in Myanmar. However, climate change and unfavourable weather conditions can cause water shortages during summer. In the dry season, frequent blackouts have occurred across Myanmar throughout the past decades. Myanmar's offshore gas can smooth out weather-pattern-related interruptions to hydropower generation. However, it also is a major source of export revenues, mainly from China and Thailand.

For Myanmar, hydropower is regarded as the mainstay for long-run electricity supply. With the implementation of market principles, independent power producers (IPPs) are considered to play a crucial role in electric power generation. Between 2017 and 2025, the MOEE is planning to develop 18 large hydropower projects, of which 14 will involve foreign investment.

Table 1: Energy power resources in Myanmar in 2019

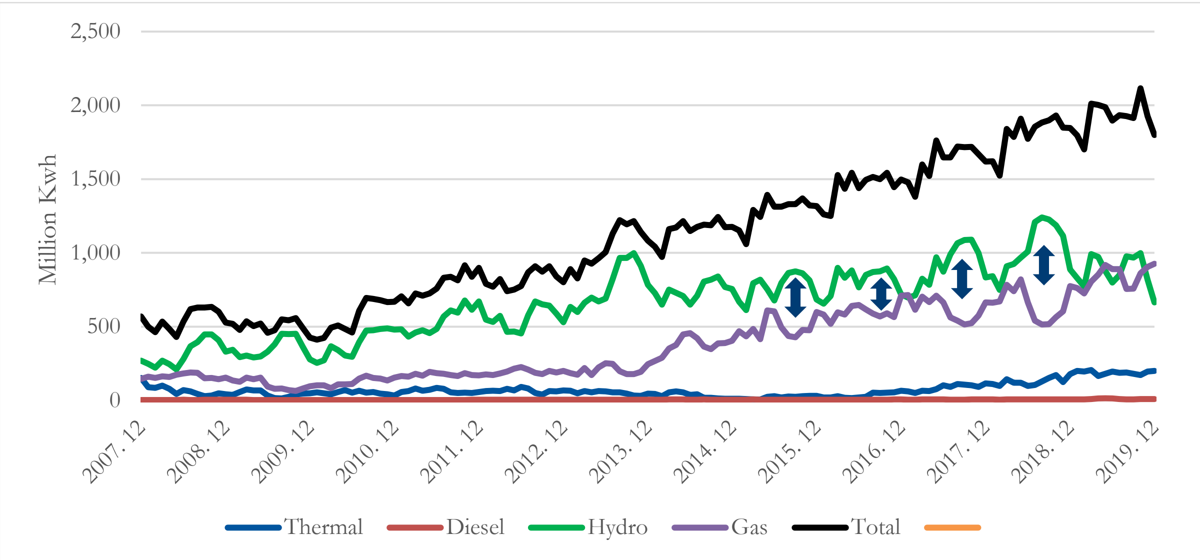
Resource	Unit	Reserve
Hydropower	Gigawatt	100 (estimate)
Crude Oil	Million barrels	145 (proven)
Natural gas	Trillion cubic feet (Tcf)	22.2 (proven)
Coal	Million tons	711 (estimate, 1% proven*)
Wind	Terawatt-hours twh/hr	365
Solar	Terawatt-hours twh/hr	52,000
Biomass (wood fuel)	Million tons/year	19.12

Note: * according to the ADB (2012: 6), only 1% of the 489 million tons of reserves at the time had been confirmed.

Source: author's construction based on EuroCham Myanmar (2019).

Figure 1 shows that electric power generation took off in the last ten years or so. While electric power from hydro increased by about 140 per cent over the last ten years (December 2009 – December 2019), most of the 320 per cent increase in total electric power generated came from gas-fired power stations, with a more than 860 per cent increase. It can also be seen that since the middle of 2013 gas generation has complemented hydro generation, with alternating peaks and troughs.

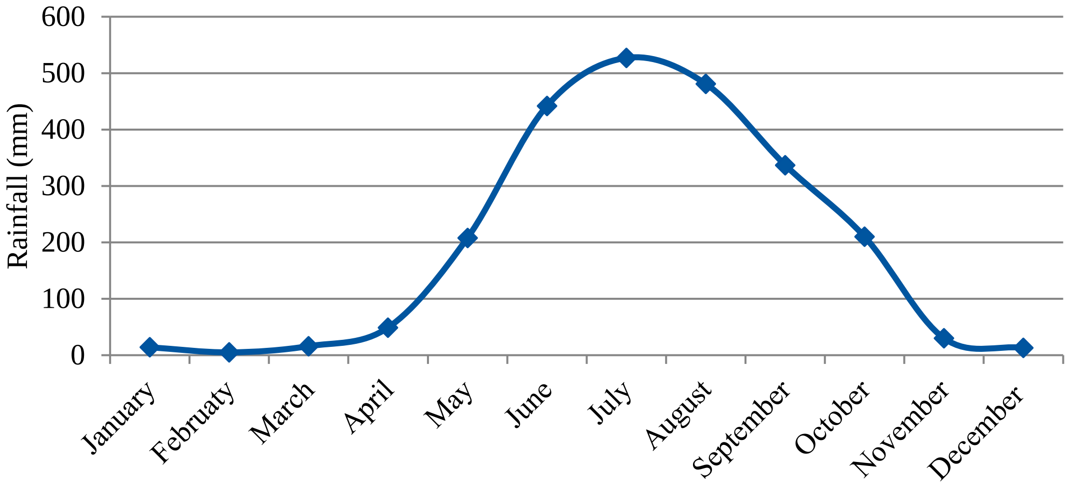
Figure 1: Electric power generation by type of energy (unit: million kwh)



Source: author's illustration based on MMSIS (ongoing).

The complementary role of gas to hydro is to accommodate the considerable variation of rainfall in Myanmar that is available for hydroelectric power generation, as can be seen in Figure 2.

Figure 2: Monthly rainfall in Myanmar (2009–18 average)



Source: author's illustration based on MMSIS (ongoing).

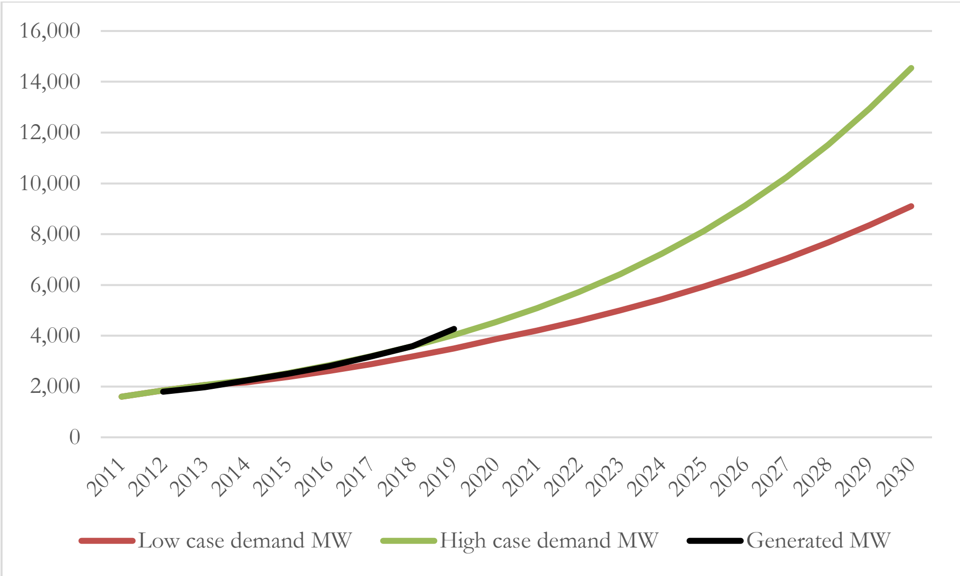
In addition to hydro and gas-fired plants, the first solar power plant in Myanmar was initiated in June 2019. It produces 40 MW out of its total capacity of 170 MW. The solar power plant was developed under a build-operate-transfer (BOT) contract. There are ongoing plans to initiate new solar investment proposals from both local and foreign investors (Frontier Myanmar 2020; The Irrawaddy 2019).

Myanmar also has potential to produce about 4,000 MW from wind energy. Yet large commercial-scale projects are still to be developed. In recent years, waste-to-energy solutions are emerging in urbanized areas. In particular, for Yangon City, the utilization of 1,000 tons of daily municipal solid waste (MSW) for power generation will be implemented by means of a soft loan from Poland (Hein and Aung 2020) and another 1,000 tons of daily MSW by using Japanese technology (Tuorila 2020). There are also small-scale biogas and biomass power plants in Myanmar which are implemented or in planning stage. Since 1980, biogas generation has been used in order to substitute fuel wood scarcity. There are seven biofuel electrical power plants (three in Yangon Region and four in Rakhine State). The first biomass gasification power plant was developed in Nay Pyi Taw (Consult-Myanmar 2017). At present, new plants are planned to be established in different regions and states of Myanmar (Aung Kaung Set 2019). These plants have the benefit of being a low-cost, renewable-fuel, low-carbon option that provides 24/7 base electricity and employment for farmers and workers.

2.2 Demand

If, as mentioned above, the aim is to electrify each household in Myanmar by 2030, demand for electricity should be considered, as it is expected to grow significantly. Projections by MOEE and the JICA suggest that demand may increase by between 7 and 12 per cent per annum over the period 2019–30 (see Figure 3).

Figure 3: Forecast demand and generated electricity for Myanmar, 2019–30



Source: author's illustration based on MOEE (2019a).

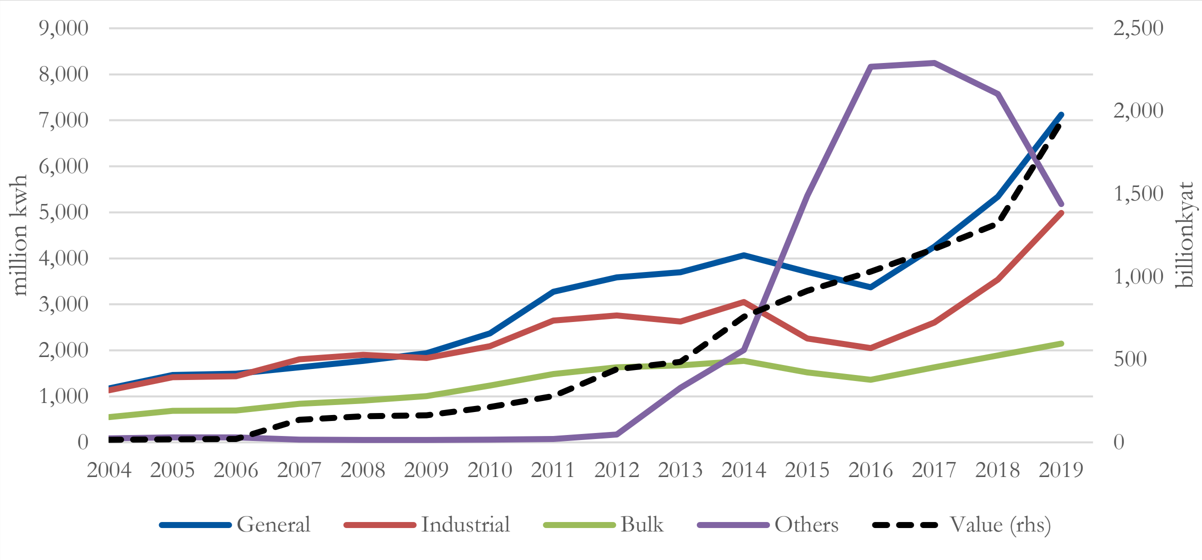
However, currently, access to electricity varies among households and firms across Myanmar. Half of the cities, towns, and villages can connect to the national grid, while the majority of rural areas cannot. At the same time, some states and regions (including Kachin, Kayin, Chin, Sagaing, and Shan) buy electricity from private providers or from neighbouring countries' gridline at higher tariffs compared with local on-grid tariffs (MMSIS ongoing).

Households' electricity consumption is increasing with the use of electrical devices (mainly mobile phones, tablets, computers, etc.) and household appliances (such as increase in the use of cooling devices, lighting, etc.). Figure 4 reports the volume of sales by broad category and the value (total only) by public sector power suppliers. Sales volumes increased steadily up to 2014 but then dipped for all categories while private sector power suppliers' sales (included here under the 'other' category) took off. This may have been a combination of an increase private sector supply[2] and a reaction to unreliable public sector supply and seems to have lasted until 2016, when supply by public sector suppliers regained ground at the expense of private sector suppliers.

The value of total sales flatlined until 2006, after which it jumped up somewhat in 2007 and 2012. A bigger jump was recorded in 2014, with an increase in the administered price of public sector supplies. The value increased steadily up to 2018 in spite of volume declines over the period 2014–16 while the new public sector supply price remained constant. The increase could possibly be attributed to rising prices of newly established private sector suppliers (part of the purple line). The value of sales increased more rapidly in the year to 2019 with the latest administered price increase. Interestingly, the volumes of public sector sales continued to rise while those of private sector sales dropped sharply. This could be related to increased reliability of public sector supply while private sector supply prices may have continued to increase, causing a shift back from the latter.

[2] Due to privatization in Yangon and Mandalay.

Figure 4: Electricity sales by volume (million kwh) and value (total only, kyat billion)



Notes: General = general purpose and domestic power; Industrial = industrial and small power; Bulk = hospitals, offices, schools, etc.; Other = street lighting and sales by private operators. Period = calendar years; from August 2012 on, units sold by private companies are included under 'Others'.

Source: author's illustration based on MMSIS (2020a).

Nevertheless, out of the total of 10,877,832 households in Myanmar, 4,111,147 had access to electric power in 2017, about 37.8 per cent. General household/domestic use accounted for 98.2 per cent of electric power used while small industry use contributed 1.8 per cent.

2.3 Electricity prices

The electricity prices of public sector suppliers are administered. As mentioned above, the most recent increases in such prices were introduced in 2014 and 2019. The impacts thereof on the value of electricity supply can to some degree be seen in Figure 4. Administered prices differ between households and businesses, with the latter in general paying a higher rate. But with the most recent increase in 2019, the rate increase for households is higher than that for businesses, as is shown in the next tables.

In Table 2, columns 1–3, the rates are as reported by MOEE (2020b) from 2014 to 2019 (MOEE, 2014) and refer to on-grid users only. The share of current users derived from an electrification utilization survey during 2017–18 by MOEE (2019b) is kept constant (assuming no change in demand; see column 4) and enables the calculation of a weighted average increase of more than 105 per cent. This suggests that the nominal electricity price more than doubled in 2019.

However, based on electricity bill increases reported in the survey, the increase is 64.8 per cent, which is only about 61 per cent of the nominal price increase, suggesting a behavioural change in demand.

On the other hand, a quick-turnaround own telephone survey with a (non-representative) sample of 400 households during August to December 2020 suggests an increase of more than 156 per cent in the electricity bill. This is a weighted average based on respondents' average monthly electricity consumption by volume and electricity bills paid based on old and new rates.

Table 2: Residential electricity price changes, 2014–19

	1	2	3	4	5	6	7	8
Bracket, per month	**Rate per unit 2014 (kyat)**	**Rate per unit 2019 (kyat)**	**Per unit rate increase (%)**	**Share of current users**	**Bracket average units per month**	**Usage 2014 (kyat, per month) (cols 5 x 1)**	**Bill increase in survey per month**	**% increase as per survey**
1 to 30	35	35	0.0	24.9	15.5	543	0	0.0
31 to 50	35	50	42.9	9.0	40.5	1,418	300	21.2
51 to 75	35	70	100.0	10.9	63.0	2,205	1,175	53.3
76 to 100	35	90	157.1	10.0	88.0	3,080	2,250	73.1
101 to 150	40	110	175.0	13.2	125.5	5,020	6,050	120.5
151 to 200	40	120	200.0	9.0	175.5	7,020	10,050	143.2
Above 200 units	50	125	150.0	23.1	600.5	30,025	0	91.4
Weighted average			106.1					64.8

Source: author's construction based on MOEE (2014, 2019b, 2020b).

Non-residential rates are reported in Table 3. Since no information could be found on utilization (demand) per bracket, it is not possible to calculate a weighted average of the nominal increase. It is probably substantially less than 80 per cent and more likely to be in the range of 20–40 per cent.

Table 3: Non-residential electricity price changes, 2014–19

	Units bracket	**Rates 2014**	**Rates 2019**	**% change**
1	1 to 500	75	125	66.7
2	501 to 5,000	105	135	28.6
3	5,001 to 10,000	105	145	38.1
4	10,001 to 20,000	125	155	24.0
5	20,001 to 50,000	125	165	32.0
6	50,001 to 100,000	150	175	16.7
7	100,000 to 300,000	150	180	20.0
8	Above 300,000 units	100	180	80.0

Source: author's construction based on MOEE (2014, 2020b).

The author's own survey mentioned above also covered 63 enterprises in the textiles and clothing industry, of which 35 per cent were small (fewer than ten employees), 48 per cent medium (less than 50), and 17 per cent employed more than 50 but less than 200 workers. About one-third operated in an industrial zone, while about 60 per cent produced fabrics and the rest manufactured clothing, of which about half engaged in exports. Respondents reported monthly electricity bills before and after the 2019 increase and based on their share in the sample's old electricity bills (which assumes no behavioural change), the weighted average increase in the electricity bill was just over 27 per cent. This result is more or less in line with the increases reported in Table 2 and suggests that although businesses pay higher electricity tariffs, their 2019 increases were lower than for households by about 50 per cent.

2.4 Supply constraints

With the transformation of political and economic systems, the composition and rate of growth of GDP is changing gradually and electricity is becoming a necessity in all economic segments (households, businesses, and government) throughout Myanmar. The contribution to GDP of industry sectors has increased from 22.6 per cent to 29.1 per cent and that of the services sector from 37.5 per cent to 48.3 per cent between 2009 and 2018. For the business and manufacturing sector, electricity plays a critical role. It is a basic input for economic growth: industrialization and economic development depend on access to electricity. The growth of the manufacturing sector (mainly garments) from 2011, higher numbers of wholesale and retail outlets, and growth of private service businesses (such as private education institutions, healthcare centres, etc.) has lead to higher demand for electricity. However, as mentioned above, there have been challenges due to frequent blackouts and insufficient supply in industrial zones and commercial areas throughout the past decade. Consequently, as a result of using private generators as back-ups, businesses have incurred additional costs for electrification.

According to the telephone interviews reported on in the previous subsection, electricity costs contributed between 4 and 10 per cent of the total production costs for firms. Yet increases in the cost of electricity are not the main challenge for producers. One of the key problems is frequent and unpredictable electricity blackouts. Unlike for households, for businesses frequent blackouts interrupt production and generate losses due to resulting difficulties in continuing computerized machines and shipping delays. For small-scale garment producers, using private diesel generators cost more compared with the increased price of on-grid electricity. Therefore, controlling frequent blackouts and supplying stable electricity is preferable for firms to reforming electricity tariffs. However, unlike the previous tariffs, the current electricity tariffs are higher for large businesses. The resulting increase in production costs affects the profitability of these businesses.

Similar mixed results are reported elsewhere. On the one hand, there is little evidence of insufficient and infrequent electricity supply causing serious supply constraints for businesses. Thus, while '[t]ownship-level data show that despite having a 98 per cent access rate to the electricity grid, 96 per cent of firms in Dagon Myothit South Township in Yangon have insufficient power for production at least once a week' (Berkel et al. 2018: 25), '[l]ack of electricity seems to be the least of producers' constraints in Myanmar' (Hansen et al. 2020: 75) 'but is one of the most important factors for high labour productivity and informal enterprises' (78). On the other hand, '[c]ontinuing to improve the electricity supply to the industrial zones in Yangon should be a high priority. Otherwise the production capacity of Myanmar's largest industrial centre remains tightly capped' (Robertson and Taung 2015: 11); 'zones in Mandalay and most non-polar zones receive electricity 24 hours per day. This has significantly expanded the production potential of businesses in the industrial zones.' (17).

2.5 Discussion

The above suggests that Myanmar has ambitious plans to connect its households to grid electricity. This requires a significant power build programme. Hydro remains the proven source of electricity given abundant availability, while solar has significant potential and gas remains a useful, if somewhat expensive, peak demand solution for the short to medium term.

In order to finance the electrification programme, it was decided to increase the administered prices of households and businesses, with the former facing a much higher increase although their rates remain lower. In an attempt to encourage higher economic growth, the electricity price increases for firms are much lower. Still, anecdotal evidence suggests that the price of electricity is not the main factor concerning firms. Rather, the irregular supply and simple lack of grid connectivity are more likely to be constraining supply and therefore productive activities.

Each of these issues will be examined with a multiplier model based on a Social Accounting Matrix for Myanmar in the next section. The modelling will focus on the impact of:

1. a large-scale power build programme;
2. electricity price increases for firms and households;
3. supply constraints on firms due to lack of sufficient or infrequent availability of electric power.

3 Methodology

The topics mentioned in the previous section will be examined with various extensions of the original input-output table (IOT) multiplier model. The first application is based on the standard demand-driven model as explained by Millar and Blair (2009: 10–26). The model is extended so that the applications can be examined using a Social Accounting Matrix (SAM) for Myanmar. The second application extends the original version of the IOT price model as explained by Millar and Blair (2009: 43–46) with the Myanmar SAM. The third application is based on a mixed type of IOT model in which one or more of the industries' outputs is exogenously determined instead of its final demand (see Millar and Blair 2009: 621–25) using the Myanmar SAM.

3.1 The demand-driven SAM multiplier model

The standard IOT model is driven by an exogenous increase in final demand for an industry's goods and services. The critical assumption is that all industries in the economy that are directly and indirectly supplying intermediate inputs to satisfy this exogenous increase in final demand can do so. Supply (or output) is perfectly elastic, which implies that prices are fixed. A generic IOT model can be presented in the following way:

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f} \quad (1)$$

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} \quad (2)$$

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{Lf} \quad (3)$$

$$\Delta\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\Delta\mathbf{f} = \mathbf{L}\Delta\mathbf{f} \quad (4)$$

in which

$\mathbf{x}$ = a column vector of industry outputs in an economy ($\mathbf{\Delta x}$ denotes a change in outputs);

$\mathbf{Z}$ = a matrix of intermediate sales/inputs in an economy;

$\mathbf{f}$ = a column vector of final demand of goods and services supplied by industries in an economy ($\mathbf{\Delta f}$ denotes a change in final demands), consisting of the sum of household demand, government expenditure, investment demand, and exports;

$\mathbf{i}$ = a column vector of unit values, so that $\mathbf{Zi}$ is a column vector of intermediate sales summed over all purchasing industries;

$\mathbf{A}$ = a matrix of intermediate demands per unit of industry output for an economy, derived by dividing $\mathbf{Z}$ by the transpose of $\mathbf{x}$, i.e., the column totals;

$\mathbf{L}$ = the Leontief matrix of direct and indirect impacts on each of the activities labelled in the row headings as a result of a one-unit increase in final demand for goods and services produced by the activity in the column heading. The column totals of $\mathbf{L}$ are referred to as the 'output multipliers'. Comparison of output multipliers offers an indication of which industry is more connected to the domestic economy and therefore acts more as a catalyst for an economy-wide increase in output.

This model can be extended by making a distinction between activities and commodities as in a supply-use table (SUT), and by including factor income as well as household income and expenditure as reported in a SAM. The generation of factor income depends on what happens to production, which is endogenous to the model. The distribution of this income to households will generate an additional 'induced' impact on output $\mathbf{x}$ in such an expanded version by assuming that this results in additional household expenditure on goods and services. The $\mathbf{A}$ matrix of the above equations is then replaced by a $\mathbf{B}$ matrix which represents not only the per unit intermediate inputs of the activities but also the per unit marketed supply of commodities, the per unit distribution of factor incomes, and the per unit expenditures on goods and services from household incomes. In addition to activity output, the vector $\mathbf{x}$ now includes total marketed supply, and factor as well as household income.

In the first application, which aims to examine the economy-wide impact of building additional electric power stations, the change in final demand ($\mathbf{\Delta f}$ in Equation 4) represent the inputs to the build programme. These inputs include building materials, labour inputs, machinery and equipment, and various services.

Results of the base model include impacts on gross sectoral output. Using further linear relationships, the model can present impact on industry-level value added, household income, imports, tax revenues, and employment, among other things. Impacts on value added (GDP at factor costs) are based on ratios of economy-wide industry-level value added to gross output. These ratios are assumed to hold at the margin and are multiplied with the output impacts ($\mathbf{\Delta x}$ in Equation 4). The same applies to imports and tax revenues.

The typical assumption about the employment impacts is the same, in that the elasticity of employment with respect to output is equal to 1. In other words, if output goes up 1 per cent, employment will also go up by 1 per cent. This may be considered as a rather more heroic assumption than the linearity of the base model itself (Bulmer-Thomas 1982: 61). Firms may hold on to labour in downturns in order to avoid costly search and training and when there is an upturn, the demand for labour may not increase. Econometric analysis is required to estimate such elasticities. Broad economy-wide estimates have been made for Myanmar by Kapsos (2005: 35) which suggest that the employment-output elasticity with respect to GDP is 0.21, almost five times lower than a unit elasticity. In the case of the first application, the employment-output elasticity is not applied to the direct (or first round, in the case of a SUT/SAM set-up) impact, so that employment impacts in dedicated input suppliers such as construction are calculated using a unit elasticity. The estimated elasticity is only applied further up the intermediate input chain and to the income–expenditure loop (induced) effects.

3.2 A SAM-based price model

The second application features the impact of electricity price increases and how they may permeate throughout the economy. To model this, increases in electricity prices are imposed exogenously. This fits the Myanmar context, since electricity prices are largely administered and a classic demand-supply model does not apply. Using an IOT-based model, a cost-push approach to the determination of prices is adopted. Electricity price increases can be seen as raising the costs of production of an activity which in turn can be pushed forward to the relevant downstream users, who repeat the same to their respective downstream users. Given the inter-industry linkages in a modelled economy based on an IOT, this process repeats itself in the same way as the multiplier impacts of an exogenous change in final demand. The difference here is that the direction is the other way around. The IOT price model works out in the downstream direction, which is the opposite to the standard IOT quantity model's upstream paths as represented by Equations 1–4 above. The IOT price model is often referred to as the 'dual' of the 'quantity' IOT model.

The degree to which costs can be loaded into the farm or factory gate price remains to be seen. As with the initial increase in costs (of electricity), the demand-supply notion is ignored; prices are determined by costs throughout the economy and quantities produced are assumed to be fixed. This mirrors the standard demand-driven IOT where prices remain fixed and quantities adjust. To create an upper bound to the final increase in each activity's prices, suppliers are able to pass 100 per cent of their cost increases on to downstream users. Production costs for an industry j are presented in an IOT as intermediate inputs by the jth column vector of the square $\mathbf{Z}$ matrix of Equation 1. A row vector in which each element records the sum of primary inputs of labour costs (possibly by type of labour), payments to the use of the production factor capital, and production taxes that vary with the level of production such as payroll taxes, is defined as $\boldsymbol{w}'$. A row vector of the total costs of production for each industry identified in the IOT can then be written as:

$$\mathbf{i}'\mathbf{Z} + \mathbf{w}' = \mathbf{x}' \quad (5)$$

The structure of production costs or per unit production cost must add to unity and can be written as:

$$\mathbf{i}'\mathbf{A} + \mathbf{v}' = \mathbf{i}' \quad (6)$$

In which $\mathbf{A}$ is the matrix of intermediate inputs coefficients (see Equation 2) and $\mathbf{v}'$ the transpose of a column vector in which each element represents the sum of the primary input costs per unit of output or the primary input cost coefficients. For the base of the model, the price index is set for each industry equal to 1. A column vector of output price indices equal to $\mathbf{p}$ is defined. In doing so, Equation 6 can be rewritten as:

$$\mathbf{p}'\mathbf{A} + \mathbf{v}' = \mathbf{p}' \quad (7)$$

Solving for $\mathbf{p}'$ and taking the transpose:

$$\mathbf{p} = (\mathbf{I} - \mathbf{A}')^{-1}\mathbf{v} \Leftrightarrow \mathbf{p} = \mathbf{L}'\mathbf{v} \quad (8)$$

In which $\mathbf{L}'$ is the transpose of the Leontief inverse of Equation 3. Small changes in the primary input cost expressed per unit of output, $\mathbf{\Delta v}$, will then result in small changes in the price indices of vector $\mathbf{p}$ and can be written as:

$$\Delta\mathbf{p} = (\mathbf{I} - \mathbf{A}')^{-1}\Delta\mathbf{v} = \mathbf{L}'\Delta\mathbf{v} \quad (9)$$

When this model is extended to a SUT and SAM framework in which the distinction is made between activities and commodities, not only the output price of the activities but also the market price of commodities can be accounted for. The primary input costs analogy of activities then extends into 'other costs of marketed commodity supply' and includes trade and transport margins, domestic product taxes, and import duties as well as imports. In this SUT expanded set-up, a round-by-round pass-through of an increase in the production costs of activity output would result first in an increase in the farm or factory gate price and subsequently in an increase in the market price of the commodities produced by the activity. The increase in the market price of commodities would then result in higher production costs for those activities that purchase these commodities as intermediate inputs, after which a new round of cost-push is to take place (in this modelled economy).

It is tempting to extend this process by replacing the **A** matrix of Equation 9 with a **B** matrix mentioned in the context of Equation 4 which also captures the factors of production and the household income and expenditure loop. This would assume that if households are faced with higher prices, they will pass these on in the form of higher wage demands. We ignore this possibility and limit the pass-through to activity output prices and commodity market prices.

Electricity price increases are the focus of our modelling. They are imposed at the factory gate of the electricity producer by a single factor. The administered price increase depends on usage (see Table 2) and may be different across activities so that the per unit cost increase will also vary. Average size of production unit per activity is, however, not accounted for in our modelling. A single average exogenous electricity cost increase is imposed as if it were a product tax (without concern for what happens to the tax revenues).

As discussed in the previous section, in Myanmar a distinction is made between administered prices for activities and for households. The increase in electricity prices for households is many times higher than that for activities. Since household are assumed not to pass their electricity price increase on to activities by demanding higher wages, the household-specific direct impact is added to the indirect impact on commodity market prices of the increase in the activities' electricity cost.

The electricity price increase of households leads to an increase in their weighted average consumer price index (CPI) based on the share of electricity in their consumption basket. But the prices of other marketed commodities are also likely to increase if activities are able to push their higher production costs on due to their, albeit lower, electricity price increases. Although the assumed 100 per cent pass-through is an upper limit, the household CPI is likely to be higher than what is associated with their initial electricity price increase. The model will give an indication of the increase in the household CPI. This depends not only on the share of electricity in the household's expenditure basket but also on the share of electricity in the costs of production of all marketed commodities, the structure of production captured by the **B** matrix, and the weight of all marketed commodities in the CPIs. The CPI weights are likely to differ between urban and rural households as well as between low- and high-income households. The respective CPI outcomes may therefore differ across household types.

3.3 A mixed SAM multiplier model to examine supply constraints

The final set of applications looks at the potential economy-wide impact of supply constraints due to insufficient and infrequent supply of electric power. In order to do that, a 'mixed' multiplier model is developed in which the change in supply (output) of one (or more) production activities is determined exogenously. In the standard demand-driven set-up, output of all activities is assumed to be endogenous. As reported in the previous section, it is possible that some Myanmar productive activities are 'unable to reach their potential' due to limited availability of electricity, and higher electricity prices may be of lesser concern to them. In order to explore this, the standard model is changed in such a way that output of all manufacturing sectors identified in the SAM is determined exogenously.

Thus, the column vector with exogenous final demand $\mathbf{f}$ in the standard demand-driven model of Equation 3 is replaced by a column vector $\mathbf{n}$ in which exogenous final demand of (at least) one activity is replaced by its output. The column vector $\mathbf{x}$ of endogenous output in the standard demand-driven model of Equation 3 is replaced by a column vector $\mathbf{m}$ in which at least one element is an activity's final demand while the rest is output. If Equation 3 can be written as

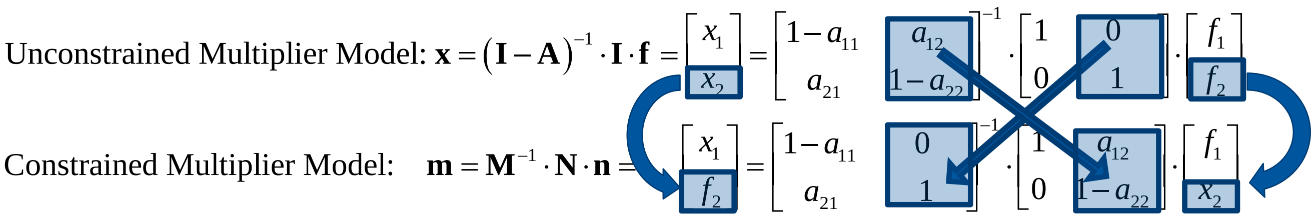
$$\mathbf{x} = (\mathbf{I} - \mathbf{A}')^{-1} \cdot \mathbf{I} \cdot \mathbf{f} \tag{10}$$

where $(\mathbf{I} - \mathbf{A}')^{-1}$ is the familiar Leontief inverse $\mathbf{L}$ and $\mathbf{I}$ is the identity matrix, the mixed model can be written as

$$\boldsymbol{m} = \boldsymbol{M}^{-1} \cdot \boldsymbol{N} \cdot \boldsymbol{n} \tag{11}$$

in which $\mathbf{M}$ is the $(\mathbf{I} - \mathbf{A})$ matrix in which the column of the supply-constrained activity is replaced with the same column of the identity matrix $\mathbf{I}$. The $\mathbf{N}$ matrix is an identity matrix in which the column of the supply-constrained activity is replaced by the matching column of the $(\mathbf{I} - \mathbf{A})$ matrix. This can be illustrated by the two industry examples in Figure 5, in which the second industry is supply-constrained:

Figure 5: Swapping final demand for output in the multiplier model



Source: author's own illustration.

The same swap needs to be made for the relevant elements of the $\mathbf{m}$ and $\mathbf{x}$ vectors and $\mathbf{n}$ and $\mathbf{f}$ vectors. Final demand $\mathbf{f2}$ is swapped with $\mathbf{x2}$ and becomes part of the vector of endogenous variables $\mathbf{m}$, while its endogenous output $\mathbf{x2}$ becomes part of the vector of exogenous variables $\mathbf{n}$.

The mixed model described above can be extended from an industry-by-industry IOT format into a SUT and SAM format. In principle this would allow the swapping to be extended as well, but for purposes of this exercise, supply constraints are imposed on activities only. The $\mathbf{A}$ matrix of intermediate input coefficients can be replaced by the $\mathbf{B}$ matrix in the same way as discussed in section 3.1.

For purposes of this exercise, two scenarios are explored. The first considers an exogenous increase in manufacturing output that is associated with more and more reliable supply of electricity, while the second takes an increase in exports of agriculture as a starting point and compares the impacts with and without a constrained supply in manufacturing.

The first scenario essentially explores the demand impacts of an increase in manufacturing output. Thus, if manufacturing can increase its output it will demand more intermediate inputs, of which production in and of itself is not constrained, unless it is supplied by manufacturing. The increase in demand for intermediate inputs as a result of the exogenous increase in production of manufacturing generates additional output in other sectors, which is what creates an impact on output, value added, employment, etc.

The second scenario compares an increase in the exports of agriculture in the standard or 'unconstrained' way, where all additional intermediate inputs are readily available (Equations 1–4), with the situation where the output of manufacturing cannot increase. In the latter case, the additional intermediate inputs of manufacturing are not available and are assumed to be drawn away from other components of final demand or supplied by imports. Either way, manufacturing output remains at the base level and all the intermediate inputs required to satisfy the increased intermediate demand for its goods by agriculture do not materialize. In this case, it is expected that the economy-wide multiplier impact on output, value added, employment, etc. of the increase in agriculture's exports will be lower, since manufacturing is not contributing to satisfying this increase in demand in the first round, while all industries that supply manufacturing with intermediate inputs will also benefit less.

4 Modelling inputs and results

The context to some of the issues relating to the electricity sector provided in Section 2 offered a reason to examine them in an economy-wide context, while Section 3 presented the tools to undertake the examination. This section will describe the modelling inputs and report on the modelling results for each of the applications described above.

4.1 Electric power build programmes

There are few data available on electric power build programmes in Myanmar. The Central Statistical Organization (CSO) reports that total installed capacity was about 5.7 GW in 2018 (MMSIS 2020b). According to Bloomberg NEF (2020), 90 per cent is hydro-electric and gas-fired and a 1 GW solar power tender was to be completed in July 2020. Various hydropower plants are being planned for the 2021–25 period with a total capacity of almost 4 GW (ADB, IES, and MMIC 2015).

Here, for illustration purposes, a capacity expansion of 1 GW is assumed for hydro, gas, and solar power. The economy-wide impact of the build programme focuses on the economic activity that is associated with the building of a hypothetical 1 GW electric power plant of the hydro, gas, and solar type. In doing so, it is necessary to detail what inputs are required to build a 1 GW hydro, gas, or solar power plant and how and where these inputs are produced. Due to lack of data, the impact analysis is limited to the construction phase and excludes the operational phase. The running costs of the hypothetical power plants are probably relatively low, with few workers employed. Hydro and solar plants use renewable sources, which as such do not add to the operational costs, although it is different with gas. These issues are all ignored by focusing only on the construction phase at this stage. The overall cost per 1 GW of installed capacity in Myanmar is reported in Table 4.

Table 4: Overnight CAPEX (investment) of selected electric power stations (per unit of capacity) in 2017 prices

	Unit	Solar	Hydro	CCGT
Plant size	MW	50	600	650
Capacity factor	%	20	50	80
Economic life	years	25	70	25
Investment	US$/kW	2,100	1,700	918
Investment	US$ m/mW	2.1	1.7	0.9
X-rate	2017 MMK/US$	1,336	1,336	1,336
Investment	2017 MMK bn/MW	2.8	2.3	1.2
O&M% of CAPEX		0.4	1.2	1.8
Investment for 1 GW	2017 MMK bn overnight	2,806	2,271	1,226

Source: author's construction based on ADB (2015: 610).

In the last row it can be seen that the investment for 1 GW of solar power is estimated to be MMK2,800 billion. This is about 24 per cent higher than for the same capacity of hydro-electric power and almost 130 per cent higher than a gas-fired electric power plant of 1 GW capacity.

Since there are no data on the inputs to power build programmes in Myanmar, use is made of studies elsewhere. The breakdown of the investments in various inputs for hydro and solar has been reported for Indonesia and is shown in Table 5.

Table 5: Cost structures for solar power and hydroelectric power investment

Solar	**% costs**	
Cost structure	*Shares*	*Model mapping*
Mining of non-ferrous	17.1	Oth Manf Prod
Smelting of non-ferrous metals and manufacturing of alloys	8.5	Oth Manf Prod
Man. of equipment for power transmission and distribution and control	11.1	Oth Manf Prod
Man. of other electronic equipment	12.7	Oth Manf Prod
Man. of special-purpose machinery for mining, metal, and construction	15.2	Oth Manf Prod
Research and experimental development	12.7	Prof, science, and tech serv
Construction	22.7	Construction
	100.0	
Hydro	**% costs**	
Cost structure	*Shares*	*Model mapping*
Civil works	37.4	Construction
Mechanical equipment	38.4	Oth Manf Prod
Grid connection	8.2	Oth Manf Prod
Planning and other	16	Prof, science, and tech serv
	100.0	

Note: 'Mining of non-ferrous' is classified by the authors as 'Metal products' and therefore mapped here to 'Oth Manf Prod'.

Source: author's construction based on Hartono et al. 2020: supplementary content, appendix table 1a.

Construction-related inputs (Civil works) are more important for establishing hydropower plants compared with solar power plants. The latter use inputs of non-ferrous mining (mapped by the authors to 'Metal products') and manufacturing products and other machinery and equipment to a larger degree.

For inputs in the construction of a gas-fired power station, information is draw from the US Energy Information Administration (EIA 2020). The average input structure of the capital costs of Case 7–9 (EIA 2020: 7.1–9.6) is taken as being representative of the establishment of a hypothetical 1 GW power plant in Myanmar. The details are shown in Table 6.

Table 6: Average cost structure for gas electric power investment

	% cost Shares	**Model mapping**
Civil/structural/architectural	7.6	Construction
Mechanical	53.2	Oth Manf Prod
Electrical	8.3	Oth Manf Prod
Indirects	20.1	Construction
Owner's services	9.1	Prof, Science & Tech Serv
Electrical interconnection	0.4	Oth Manf Prod
Gas connection	1.2	Oth Manf Prod
	100.0	

Note: not shown here are engineering, procurement, and construction (EPC) fees which are specified in the original documentation. They are assumed to be distributed in the same proportion as the other expenditure items. Land costs specified in the original documentation are not assumed to create multiplier effects.

Source: author's construction based on EIA (2020: 7.1–9.6).

The structure of the EIA gas-fired power plant capital outlays is similar (after aggregation to the same level of input detail) to that examined in a study conducted in Cyprus by Taliotis et al. (2020).

The costs shares of Table 5 and Table 6 are mapped to SAM commodities in the last column of the relevant tables and multiplied by the total investment for 1 GW capacity reported in the last row of Table 4. The results of these multiplications constitute the $\mathbf{\Delta F}$ of Equation 4, now a rectangular matrix of three column vectors, one for each power build option.

Headline results are reported in Table 7. The first column shows the base levels for the relevant variables as reported in the 2017 SAM. They are used here as reference points. Columns 2–4 show the impacts in value terms while the last three columns report the percentage change from the base values in column 1. The first panel shows initial impacts on total demand and total output. Total demand is the size of the investment for each build option and is the same as the last row of Table 4. For example, a 1 GW investment in solar represents 1.2 per cent of total demand (final plus intermediate) in the Myanmar economy of 2017.

Thus, in the first row the initial impact is expressed in terms of *commodity demand*. The initial impact on *activity output* can be calculated by post-multiplying $\mathbf{\Delta F}$ by the $\mathbf{B}$ matrix and summing the results across all activities. These results are shown in row 2. Compared with the first row, the level of impacts is much lower because not all of the initial demand of the first row can be satisfied by local producers. The relative impact is, however, quite similar, as can be seen in the last three entries of row 2 compared with row 1.

In rows 4–7, the full—i.e., initial—first round and further indirect effects are accounted for and expressed in terms of GDP, tax revenues, imports, and employment by summing over the relevant dimensions. GDP and employment impacts are calculated at the activity level, while imports are summed over commodities. Tax revenues are also summed over commodities for indirect taxes and over institutions for direct taxes on enterprises (corporate tax) and on households (income tax).

Table 7: The impact of capital outlays for selected electric power builds (MMK billion)

		1	2	3	4	5	6	7
		Base	**Solar**	**Hydro**	**Gas**	**Solar**	**Hydro**	**Gas**
					Initial impact, MMK bn			*% impact*
1	Total demand	233,251	2,806	2,271	1,226	1.2	1.0	0.5
2	Total output	178,219	1,946	1,745	857	1.1	1.0	0.5
					Full impact, MMK bn			*% impact*
4	GDP	83,818	2,669	2,367	1,165	3.2	2.8	1.4
5	Tax revenues	6,100	209	190	92	3.4	3.1	1.5
6	Imports	25,316	1,366	999	601	5.4	3.9	2.4
7	Employment ('000)	21,912	206	199	95	0.9	0.9	0.4
	Employment (full)	21,912	600	540	268	2.7	2.5	1.2
					Multipliers			
8	GDP		0.95	1.04	0.95			
9	Tax revenues		0.07	0.08	0.08			
10	Imports		0.49	0.44	0.49			
11	Employment		0.07	0.09	0.08			

Source: author's construction based on own caculations.

In row 4 of Table 7, it can be seen that GDP is expected to increase by 3.2 per cent when the construction of a 1 GW solar power farm is completed. Since it is not known how long the construction phase will last, it is unclear what the annual impact is. Still, this impact seems rather high, but it should be noted that it is dependent on the degree to which productive activities in Myanmar are actually able to supply inputs to the construction process. Here, the assumption is made that this is the same as the industry average of the relevant activities. This may be the case to a fairly high degree for construction goods and services but perhaps not for goods supplied by manufacturing. Solar power plants require inputs of sophisticated manufacturing products. The information used here is based on data from Indonesia, which is a much larger economy with a more developed manufacturing sector. Thus, the Indonesian economy may be able to supply some of these inputs locally, which may not be the case in Myanmar—at least not at this stage.

Thus, in Tables 5 and 6 it can be seen that all non-construction and other services are mapped to the catch-all activity of 'other manufacturing' simply because there is not more detail available in the underlying SAM. Therefore, the average import penetration of the 'other manufacturing' activity applies. This may underestimate the import penetration of the manufacturing goods that are specific to the establishment of a solar electric power unit.

A small diversion, not shown here, is that if all 'other manufacturing' commodities that are required as direct inputs in the construction needed to be imported, the direct and indirect impact on GDP would be more than 50 per cent lower. This also applies to gas, but to a lesser degree to hydro since the latter relies relatively more on the locally biased construction sector. Full import penetration can be considered as a lower bound to the GDP impacts. Similar downgrades can be expected for the tax revenue and employment impact reported in Table 7.

In terms of employment, use is made of an economy-wide employment-output elasticity of 0.21 estimated for Myanmar by Kapsos (2005: 35) for demand multiplier impacts that are beyond the first round. The impact is shown in row 7 of Table 7.[3]

Thus, total employment, i.e. the total number workers, ranges from 200,000 for solar and hydro to about 100,000 for gas over the period of construction. If that period is two years, this means between 50,000 and 100,000 per year[4] for those two years. The employment will evaporate once the electric power plant is completed.[5]

We can also calculate project-specific multipliers by taking the ratio of the impact for any of the variables to the initial injection, with the latter being the value of the capital outlay for 1 GW of installed capacity. In row 8 of Table 7 it can be seen that for every MMK1 billion of capital outlay in solar power, hydro, and gas, GDP will increase directly and indirectly by MMK0.95 billion, MMK1.04 billion, and MMK 0.95 billion respectively. Tax revenues increase due the direct and indirect economic activity by MMK0.07–0.08 billion. The direct and indirect imports associated with the capital outlay are relatively high, at about half the size of the GDP impact, suggesting limited contributions by local producers,[6] albeit somewhat more for the hydro option. The reason that the hydro is less import-intensive and indeed more labour-intensive (see row 11) relative to the other options is that it requires more construction inputs. The employment multiplier for hydro should be interpreted as 0.09 × 1,000 = 90 workers over the whole construction period per MMK1 billion in capital outlay.

Detailed activity-level GDP impacts are shown in Table 8, in which the full impact is accounted for if manufacturing commodities are supplied locally according to average import penetration as observed in the underlying SAM/SUT data. Results are reported in terms of GDP of the top 20 industries (out of a total of 43). It can be seen that the wholesale and retail trade sector benefits the most from this injection into the Myanmar economy. This is in spite of this activity not directly supplying inputs to any of the three hypothetical power build programmes. The reason is the relatively high trade margins that are identified in the underlying SAM data, which in turn rely on the SUT data on which they are based. Trade margins are raised on products and subsequently channelled to the wholesale and retail trade activity. Some trade margins in the underlying data constitute high proportions of total supply, as this may account for poor infrastructure and transport services. In particular this applies to agricultural goods, with margin rates of more than 40 per cent, and manufactured goods, with rates between 10 and 20 per cent.[7]

The next three activities are direct beneficiaries of the build programme while the other activities benefit indirectly. The impacts on food-related and consumer goods such as textiles and clothing

---

[3] Below row 7 in a shaded font, the unit elasticity results are shown as a matter of interest. For the solar and gas option, the employment impact could be about one-third of the full impact based on unit employment-output elasticities but about half in case of the hydro build. The latter is less impacted because more construction inputs are required in the first round.

[4] Note (but not shown here) that lower-bound employment estimates based on the complete lack of direct local manufacturing input would reduce the employment impact a further 44%, 27%, and 42% for solar, hydro, and gas respectively.

[5] GDP and employment impacts associated with the *operation* of the power plants are not considered in this study due to lack of data.

[6] Note that economy-wide average input structures and import dependencies as reported in the SAM are assumed here. It is possible that a large proportion if not all manufacturing inputs are imported, as discussed earlier.

[7] Agriculture benefits indirectly through the induced effects associated with the household income–expenditure loop.

can be attributed to the household income–expenditure loop. This suggests that the build programmes can expect to have widespread effects in the Myanmar economy.

Table 8: Detailed impacts of capital outlays for selected electric power builds on activity GDP (MMK billion)

	Solar	Solar	Hydro	Hydro	Gas	Gas
1	Wholesale & Retail	713	Wholesale & Retail	568	Wholesale & Retail	315
2	Oth Manf Prod	497	Construction	346	Oth Manf Prod	218
3	Prof, Science & Tech Serv	278	Oth Manf Prod	341	Construction	138
4	Construction	259	Prof, Science & Tech Serv	283	Prof, Science & Tech Serv	88
5	Food, Bev &Tob Prod	104	Food, Bev &Tob Prod	93	Food, Bev &Tob Prod	46
6	Land Transport	87	Fisheries	75	Land Transport	37
7	Fisheries	84	Land Transport	73	Fisheries	37
8	Other Crops	59	Other Crops	54	Other Crops	25
9	Paddy	54	Non-Met Min Prod	51	Paddy	24
10	Livestock	54	Livestock	49	Livestock	24
11	Owner Occup Dwell	45	Paddy	49	Non-Met Min Prod	21
12	Restaurants	42	Owner Occup Dwell	41	Owner Occup Dwell	20
13	Non-Met Min Prod	41	Restaurants	38	Restaurants	18
14	Dom & Oth Serv	35	Dom & Oth Serv	31	Dom & Oth Serv	16
15	Electr, gas & Steam	31	Electr, gas & Steam	26	Electr, gas & Steam	14
16	Wearing App & Text	28	Wearing App & Text	25	Wearing App & Text	12
17	Beans	25	Beans	22	Beans	11
18	Oth Min Incl Supp Serv	24	Oth Min Incl Supp Serv	20	Oth Min Incl Supp Serv	11
19	Coke & Petrol Prod	21	Coke & Petrol Prod	18	Coke & Petrol Prod	9
20	Banking	19	Banking	17	Banking	8
	Other	169	Other	149	Other	74
	Total	2,669	Total	2,367	Total	1,165

Source: author's construction based on own calculations.

Table 9 repeats the same as in Table 8 but now for employment. The relatively labour intensity of construction moves this industry to the top of the top 20 ranking, followed by manufacturing (again, assuming that this sector can indeed supply the hypothetical power build programmes). Wholesale and retail is still important in terms of employment, but the third direct beneficiary of the build programme is less labour-intensive, as one would expect from the 'professional, scientific, and technical services' activity.

Table 9: Detailed impacts of capital outlays for selected electric power builds on activity employment ('000)

	Solar	Solar	Hydro	Hydro	Gas	Gas
1	Construction	61	Construction	81	Construction	32
2	Oth Manf Prod	41	Oth Manf Prod	25	Oth Manf Prod	18
3	Wholesale & Retail	26	Wholesale & Retail	21	Wholesale & Retail	11
4	Paddy	21	Paddy	19	Paddy	9
5	Other Crops	10	Other Crops	9	Other Crops	4
6	Prof, Science & Tech Serv	7	Prof, Science & Tech Serv	7	Beans	3
7	Beans	6	Beans	5	Dom & Oth Serv	2
8	Dom & Oth Serv	6	Dom & Oth Serv	5	Land Transport	2
9	Land Transport	5	Land Transport	5	Prof, Science & Tech Serv	2
10	Fruits	3	Fruits	3	Wearing App & Text	1
11	Wearing App & Text	3	Wearing App & Text	3	Fruits	1
12	Vegetables	3	Vegetables	3	Vegetables	1
13	Food, Bev &Tob Prod	3	Food, Bev &Tob Prod	2	Food, Bev &Tob Prod	1
14	Fisheries	2	Fisheries	2	Fisheries	1
15	Oth Min Incl Supp Serv	2	Non-Met Min Prod	2	Oth Min Incl Supp Serv	1
16	Non-Met Min Prod	1	Oth Min Incl Supp Serv	1	Non-Met Min Prod	1
17	Forestry and Logging	1	Forestry and Logging	1	Forestry and Logging	1
18	Livestock	1	Livestock	1	Livestock	0
19	Hotels	1	Hotels	1	Hotels	0
20	Construction	61	Construction	81	Construction	32
	Other	3	Other	3	Other	1
	Total	206	Total	199	Total	95

Source: author's construction based on own calculations.

The impact on household income in rural and urban areas is shown in Table 10. Note that the model is agnostic in terms of the location of the electrical power station to be built. The SAM only identifies one economy-wide factor (and therefore labour) market and ignores regional differences in employment intensities of activities. It can be seen that the share of the impact on total household income, shown in columns 5–7, favours low-income rural households more than other income groups and it is also slightly higher than in the base for all build options. The same applies to the impact on low-income urban households.

Table 10: Impacts of capital outlays for selected electric power builds on household income (MMK billion)

		1	2	3	4	5	6	7	8
		Base	**Solar**	**Hydro**	**Gas**	**Base**	**Solar**	**Hydro**	**Gas**
			MMK billion				*% share of impact*		
1	Rur low inc.	30,912	886	798	394	43.4	43.7	44.0	44.2
2	Rur high inc.	12,746	352	317	156	17.9	17.4	17.5	17.5
3	Urb low inc.	10,772	317	281	138	15.1	15.6	15.5	15.5
4	Urb high inc.	16,837	473	417	203	23.6	23.3	23.0	22.8
5	Total	71,267	2,028	1,813	890	100.0	100.0	100.0	100.0

Source: author's construction based on own calculations.

The relative impact is, however, very similar across the build options.

Note that funding issues and impacts on macro investment in Myanmar, whether this is private or public, are not considered, nor are the potential positive effects from improved labour productivity and investment climate. Such impacts are better suited to being examined using a computable general equilibrium (CGE) model. The impacts of supply constraints are dealt with later in this section.

4.2 Electricity price increases

Electricity price increases are administered in Myanmar. The latest electricity price increase was implemented in 2019. The discussion in Section 2.3 suggests that electricity price increases may have been in the order of 30 per cent for activities and about 60 per cent for households .

Note that electricity's basic price—i.e. at factory gate, as it were—represents about 75 per cent of the market price. The latter includes margins, product taxes, and imports. For the purpose of convenience here, the assumption is made that the costs of none of these elements will change. Therefore, the initial increase in the marketed electricity price that is charged is about 22.5 per cent for activities and 45 per cent for households. The former enters the price model described in Section 3.2, Equation 9, as a domestic commodity price increase at market price. For households, the 45 per cent direct price increase replaces the modelled direct electricity price increase of 22.5 per cent for businesses . Since households are not assumed to demand higher wages, which in turn could raise production costs and prices, a simple ex-post swap of the direct element of the full electricity price increase is sufficient.

The headline results are shown in Table 11, where the first row shows the weighted average direct increase in the relevant price indices. In the case of activity output—measured in basic prices, a producer price index (PPI) of sorts—the direct increase is 0.54 per cent, which is the multiplication of the initial increase of 30 per cent and the 1.8 per cent weight of electricity in the sum of the activities' output. Similarly, the direct impact on rural households' CPI is 0.6 per cent, and on urban households' CPI it is 1.54 per cent. For all low-income households (quintiles 1–4), the weighted average increase in the CPI is 0.75 per cent and for high-income households it is 1.28 per cent, while the average increase for all households is 0.96 per cent.

The rural household impact is lower than the impact on urban households mainly because the weight of electricity purchases in their expenditure basket, which initially increased by 45 per cent, is lower. For the same reason, the impact on low-income households is also lower than the impact on high-income households. Since very little electricity is being sold to other countries (exported), the initial export price increase is only 0.04 per cent. This is unlikely to have much impact on international competitiveness

Table 11: Weighted average price index impacts for an electricity price increase of 30% for activities and 60% for households (% change)

		1	2	3	4	5	6	7
		Activity output at basic prices	**Rural hh at market prices**	**Urban hh at market prices**	**Low-income hh at market prices**	**High-income hh at market prices**	**All hh at market prices**	**Exports at market prices**
1	direct impact	0.54	0.60	1.54	0.75	1.28	0.96	0.04
2	full impact	1.32	1.45	2.33	1.61	2.05	1.79	0.59
3	indirect impact	0.77	0.85	0.79	0.86	0.77	0.82	0.55
4	indirect impact (%)	58.81	58.33	33.80	53.38	37.52	46.06	92.86

Note: hh = households.

Source: author's construction based on own calculations.

The full impact is shown in Table 11, row 2, and includes the knock-on cost-push effects where each supplier is assumed to be able to raise their price by their increase in costs. Initially, the cost increase will emanate only from the electricity price increase and the weight of electricity costs in the total costs of an activity. But in the next and subsequent rounds, all output prices will have increased if these initial electricity cost increases were pushed forward to the full extent. Thus, the PPI increase for activity output is 1.32 per cent.

For households, the CPI increases by 1.8 per cent, with a lower increase for those in rural areas and lower-income groups of 1.45 per cent and 1.61 per cent respectively and a higher increase for urban and high-income households of 2.33 per cent and 2.05 per cent respectively. The weight of electricity in the respective household expenditure baskets matters, since the indirect knock-on cost-push effects shown in row 3 are relatively similar across the household income groups identified in the table. Given that the direct impact of the electricity price increase is relatively higher due to the higher weight in the expenditure baskets for urban and high-income households, the indirect effect is relatively lower (see row 4). The significance is that rural and low-income households suffer relatively more from the economy-wide knock-on cost-push effects.

Thus, while it appears to be the intention of the electricity price increase to hit households harder and the assumption may have been that rural and low-income households were to some degree sheltered from it due to the relatively low share of electricity in their expenditure basket, the potential indirect knock-on cost-push effects will not necessarily protect them more than high-income and urban households: they all suffer roughly similar knock-on price-raising effects.

Table 12 presents detailed impacts on the top 20 activity output prices (at basic prices) and commodity supply prices (at market prices). Note that the latter applies to households as commodity supply increases for intermediate use are based on the lower initial price increase of 22.5 per cent that is assumed for productive activities. In the first column, it can be seen that the electricity price increase at basic prices is lower than the electricity supply price at market prices, since the latter includes the higher assumed increase for households. While the initial increase for households was assumed to be 60 per cent at basic prices, the actual market price equivalent thereof is lower if it is assumed the costs of other components such as margins, commodity tax, and imported electricity do not change. That the final price increase of electricity is more than the initial price increase of about 30 per cent for activities and about 45 per cent for households is due to the additional cost increases that the electricity activity itself is faced with when purchasing intermediate inputs to generate electricity. These knock-on cost-push effects raise the price of electricity by an additional 1.5 percentage points.

Table 12: Detailed impacts on activity output prices (at basic prices) and commodity supply prices (at market prices, for households)

	% change in activity output prices at basic prices		**% change in commodity supply prices at market prices**	
1	Electr, Gas & Steam	31.7	Electr, Gas & Steam	46.3
2	Print & Repro of Rec Media	3.2	Print & Repro of Rec Media	2.6
3	Oth Min Incl Supp Serv	2.6	Oth Min Incl Supp Serv	1.8
4	Wearing App & Text	2.3	Real Estate	1.7
5	Real Estate	1.7	Wearing App & Text	1.6
6	Coke & Petrol Prod	1.6	Food, Bev & Tob Prod	1.1
7	Food, Bev & Tob Prod	1.4	Coke & Petrol Prod	0.7
8	Land Transport	1.0	Land Transport	0.6
9	Oth Manf Prod	0.9	Education	0.6
10	Non-Met Min Prod	0.7	Restaurants	0.6
11	Dom & Oth Serv	0.6	Air Transport	0.6
12	Education	0.6	Dom & Oth Serv	0.6
13	Restaurants	0.6	Oth Manf Prod	0.5
14	Wareh & Trnsp Supp Serv	0.5	Non-Met Min Prod	0.5
15	Public Admn	0.4	Wareh & Trnsp Supp Serv	0.4
16	Water Transport	0.4	Public Admn	0.4
17	Health	0.3	Water Transport	0.4
18	Telecommunication	0.3	Health	0.3
19	Construction	0.3	Construction	0.3
20	Air Transport	0.3	Publishing & Media Serv	0.2

Source: author's construction based on own calculations.

The dilution of the market price increases in the second column compared with the first column is also the result of the additional components of the market price—mentioned above—not increasing.

Other top price increases are reported for Print & Repro of Rec Media, Oth Min Incl Supp Serv, Wearing App & Text, Real Estate, Coke & Petrol Prod, Food, Bev & Tob Prod, and Land Transport. All these activities and their associated commodities are relatively high users of electricity, not only directly but also indirectly through the purchase of intermediate inputs that are used in their production.

4.3 Supply constraints due to insufficient and infrequent electricity supply

The previous subsection noted that manufacturing sectors identified in the modelled economy based on the underlying SAM/SUT data may be relatively more exposed to higher electricity prices than other sectors. In Section 2.4, some anecdotal evidence was presented and discussed which suggests that manufacturing in particular is vulnerable to insufficient and infrequent supply of electricity and that this is more of a constraint to the industry reaching its full potential than the rising costs of electricity.

In this section, a number of scenarios around the concept of supply constraints will be examined. The first scenario will examine the situation in which all manufacturing sectors are able to expand their production by a hypothetical rate of 10 per cent over their 2017 base values in the SAM. This increase is assumed to be associated with more and more frequent availability of electricity. This may be one way of quantifying the economy-wide costs of insufficient and infrequent availability of electric power.

The modelling approach here is to constrain the supply of all manufacturing activities and swap their final demand for gross output. A column vector $\mathbf{\Delta n}$ is developed which contains non-zero entries for the manufacturing activities representing 10 per cent of their base level of output and zero entries elsewhere. This vector will replace the vector $\mathbf{n}$ in Equation 11. Keeping the matrices $\mathbf{M}$ and $\mathbf{N}$ fixed, a change in the endogenous variables of column vector $\mathbf{\Delta m}$ can then be calculated (replacing vector $\mathbf{m}$ in Equation 11). Headline results are shown in Table 13.

Table 13: Headline direct and indirect impacts of a 10% increase in all manufacturing production (MMK billion)

		1	2	3
		Base levels	**Impact levels**	**% change**
1	Output	178,219	10,499	5.9
2	GDP	85,535	3,899	4.6
3	Total hh income	71,267	2,990	4.2
4	Low-income hh	41,684	1,798	4.3
5	High-income hh	29,583	1,191	4.0
6	Employment	21,912	234	1.1

Source: author's construction based on own calculations.

GDP is expected to rise by 4.6 per cent. This includes the initial 10 per cent increase in output of all manufacturing industries (Food, Bev & Tob Prod, Wearing App & Text, Print & Repro of Rec Media, Coke & Petrol Prod, Non-Met Min Prod, Oth Manf Prod) as well as the GDP embedded in the production of other activities that is required to satisfy their increase in intermediate demand for commodities and services (including themselves). In addition, payments to factors of production are distributed to households, which are assumed to spend their additional income on goods and services, thereby increasing demand in the economy and raising GDP even further. In rows 3–5 it can be seen that this favours low-income households slightly more than high-income households. In terms of employment the impact is much lower, since the economy-wide employment elasticity of 0.21 estimated by Kapsos (2005: 35) that was used in Section 4.1, still applies—now to all multiplier rounds.

Detailed results for the top 20 activities with the highest increase are shown in Table 14. Apart from the manufacturing activities, fisheries, electricity, forestry, paddy, warehousing, other mining and trade, and transport services are some of the activities that benefit indirectly as suppliers to manufacturing or to other activities that are supplying manufacturing or those that are satisfying household demand.

Table 14: Detailed impacts on activity output and employment (top 20)

	% change in activity from base output		% chane in activity from base employment	
1	Food, Bev & Tob Prod	10.0	Food, Bev & Tob Prod	2.1
2	Wearing App & Text	10.0	Wearing App & Text	2.1
3	Print & Repro of Rec Media	10.0	Print & Repro of Rec Media	2.1
4	Coke & Petrol Prod	10.0	Coke & Petrol Prod	2.1
5	Non-Met Min Prod	10.0	Non-Met Min Prod	2.1
6	Oth Manf Prod	10.0	Oth Manf Prod	2.1
7	Fisheries	8.3	Fisheries	1.7
8	Electr, Gas & Steam	7.6	Electr, Gas & Steam	1.6
9	Forestry and Logging	7.2	Forestry and Logging	1.5
10	Paddy	6.7	Paddy	1.4
11	Wareh & Trnsp Supp Serv	6.6	Wareh & Trnsp Supp Serv	1.4
12	Oth Min Incl Supp Serv	5.7	Oth Min Incl Supp Serv	1.2
13	Wholesale & Retail	5.2	Wholesale & Retail	1.1
14	Dom & Oth Serv	5.1	Dom & Oth Serv	1.1
15	Air Transport	4.6	Air Transport	1.0
16	Water Transport	4.5	Water Transport	0.9
17	Fruits	4.4	Fruits	0.9
18	Publishing & Media Serv	4.2	Publishing & Media Serv	0.9
19	Land Transport	4.0	Land Transport	0.8
20	Real Estate	4.0	Real Estate	0.8

Source: author's construction based on own calculations.

Another way to examine the potential costs of insufficient and infrequent supply of electricity is to consider the inability of the manufacturing industries to respond to an increase in demand for its products by another industry. This can be approached by assuming an exogenous increase in exports of agriculture while keeping the supply of all manufacturing activities fixed. This will allow a comparison of an export increase by agriculture with and without hypothetical constraints associated with insufficient and infrequent supply of electricity. For this experiment, the exports of all agricultural products, including livestock, forestry, and fishing, are raised by 10 per cent. The headline results are shown in Table 15.

It can be seen in row 2 that if manufacturing output is hypothetically constrained by insufficient and irregular electricity supply, GDP will increase by 0.4 per cent if agriculture's exports increase by 10 per cent. If, however, manufacturing output is unconstrained due to sufficient and regular electricity supply, GDP will increase by 0.5 per cent. In level terms, the difference is almost 30 per cent. Relative to GDP, the difference is 0.2 percentage points.

Interestingly but not surprisingly, high-income households suffer more than low-income households from this constraint. This is the corollary of the impact reported in Table 13: low-income households benefit relatively more from a positive impact and therefore relatively less from a negative impact associated with the supply of manufacturing goods.

Table 15: Headline direct and indirect impacts of a 10% increase in all agriculture's exports with and without supply constrained in manufacturing (MMK billion)

		Constrained impact	% change	Unconstrained impact	% change	Constrained—Unconstrained	
						% difference	Percentage-point difference
1	Output	440	0.25	802	0.45	−45.2	−0.20
2	GDP	323	0.38	457	0.53	−29.2	−0.16
3	Total hh income	270	0.38	373	0.52	−27.7	−0.15
4	Low-income hh	169	0.41	232	0.56	−27.0	−0.15
5	High-income hh	101	0.34	142	0.48	−28.9	−0.14
6	Employment	41	0.19	50	0.23	−17.4	−0.04

Source: author's construction based on own calculations.

Detailed results are shown in Table 16, expressed in terms of gross output. The largest percentage differences are by design for the manufacturing subsectors. Beyond that, notable negative impacts are recorded for example for electricity, mining, and fuel minerals. Thus, if manufacturing activities are constrained in producing the additional intermediates to satisfy directly and indirectly the 10 per cent increase in exports of agricultural products, the impact on the electricity sector's output is 70 per cent lower—MMK4 billion—compared with the situation in which manufacturing is not constrained, where it is MMK12 billion.

Some agricultural activities are impacted negatively because they produce also for the local market, which finds its way, as intermediate inputs, into other agricultural activities via the manufacturing activity. This channel is now closed off due to the assumed supply constraints on manufacturing.

In the last column, the differences are expressed in terms of the activities' base-level production. In the case of food processing (second entry), the assumed reduction in production is MMK142 billion, which represents 0.49 per cent of its gross output. Since the model is linear in nature, this represents the same decrease in GDP.

A range of other activities feature in the top 20, which suggests wide spread of economy-wide impacts that are ultimately all associated with the assumed insufficient and infrequent supply of electricity to the manufacturing sector.

Table 16: Detailed differences between constrained and unconstrained impacts on activity output and employment (MMK billion, top 20)

	Constrained vs unconstrained % difference in level output impact	Constrained	Unconstrained	% difference	Constrained vs unconstrained difference in relative output impact	Percentage-point difference
1	Food, Bev & Tob Prod	0	142	−100.0	Coke & Petrol Prod	−0.50
2	Wearing App & Text	0	19	−100.0	Food, Bev & Tob Prod	−0.49
3	Print & Repro of Rec Media	0	12	−100.0	Fisheries	−0.39
4	Coke & Petrol Prod	0	19	−100.0	Paddy	−0.31
5	Non-Met Min Prod	0	3	−100.0	Print & Repro of Rec Media	−0.30
6	Oth Manf Prod	0	32	−100.0	Wearing App & Text	−0.30
7	Oth Min Incl Supp Serv	0	2	−80.3	Wareh & Trnsp Supp Serv	−0.28
8	Electr, Gas & Steam	4	12	−69.6	Electr, Gas & Steam	−0.27
9	Fuel Minerals	1	4	−65.3	Forestry and Logging	−0.22
10	Fisheries	14	31	−55.9	Wholesale & Retail	−0.19
11	Prof, Science & Tech Serv	0	1	−55.0	Dom & Oth Serv	−0.18
12	Dom & Oth Serv	6	10	−42.8	Air Transport	−0.16
13	Travel Agencies	1	2	−40.2	Water Transport	−0.16
14	Restaurants	9	15	−39.0	Fruits	−0.15
15	Water Transport	4	7	−38.7	Livestock	−0.15
16	Wareh & Trnsp Supp Serv	3	4	−37.0	Beans	−0.15
17	Insur & Oth Fin Aux Serv	0	0	−36.7	Publishing & Media Serv	−0.15
18	IT Serv	0	1	−36.3	Land Transport	−0.14
19	Livestock	14	22	−36.2	Oth Manf Prod	−0.14
20	Publishing & Media Serv	0	0	−35.3	Vegetables	−0.14

Source: author's construction based on own calculations.a

5 Conclusions

This report has argued that electricity supply plays an important role in the Myanmar economy and that insufficient and infrequent availability thereof can have far-reaching consequences, some of which are not obvious at first. It highlights the importance of understanding the network of inter-industry interactions even in an economy that is not as interconnected as most. The road to such higher levels of connectivity among industries can easily be disrupted by one link not working properly. In that case, all activities on the other side of the broken link are left stranded. If that happens, the multiplier process quickly starts to push in an undesirable direction, with significant collateral damage on its way.

The modelling used in this report to highlight such undesirable impacts is based on a number of assumptions. They are more than what is preferred, but the results can still be useful for thinking about linkages and the lack thereof in the Myanmar context. Moreover, the modelling can be refined if more detailed Myanmar-specific data are available. A number of interesting observations can be made on the results.

There is a widespread economy-wide impact associated with an electric power build programme, even if the assumptions are relatively crude. Adding 1 GW generation capacity to what is currently available has a big impact. This does, however, depend on the import penetration of sophisticated manufacturing goods, in particular for the solar and gas option. A simple alternative scenario suggests that the impact may be up to 50 per cent lower than what is reported if all direct manufacturing inputs into the construction of a power station have to be imported.

In order to finance the expansion of electricity generation capacity, it was deemed necessary to raise the tariffs in 2019. While the latest round of electricity price increases mainly targeted households in an apparent attempt to protect business activity and thereby economic growth, a multiplier cost-push analysis suggests that this could create a double whammy for households. Not only will they be faced with much higher initial electricity prices, but the higher operating costs of business activities, albeit at an lower initial rate of increase, will permeate through the economy if a cost-push type of approach is assumed. The share of electricity in the expenditure baskets of rural and low-income households is relatively low compared with that of their urban and higher-income counterparts. However, the knock-on effects on prices of other goods and services will hit all households, and those in rural areas and on low incomes relatively more.

While price increases do hurt businesses and economic activity, some anecdotal evidence suggests that supply constraints due to insufficient and infrequent availability of electricity are more of a concern to them. In the last set of scenarios, albeit hypothetic, it is first shown that if more and more frequent availability of electricity raises output in all manufacturing industries, this may give a significant boost to economic growth. There is not only a direct impact but also an indirect impact that works through the backward linkages of the manufacturing industries. These linkages extend to the income of the factors of production as well as household income and expenditure.

In a second variation on this theme, it is shown that supply constraints in manufacturing may hamper the good intentions of other policy interventions such as a drive to promote exports of agriculture. In that case, manufacturing activities are assumed to be unable to satisfy the indirect demand for their goods and as a result, other industries feeding into manufacturing will also be cut off from the indirect benefits that emanate for increased exports of agriculture.

References

ADB (Asian Development Bank) (2012). 'Myanmar: Energy Sector Initial Assessment'. Mandaluyong City: ADB. Available at: https://www.adb.org/sites/default/files/institutional-document/33719/files/myanmar-energy-sector-assessment.pdf (accessed 7 January 2021).

ADB, IES (Intelligent Energy Systems), and MMIC (Myanmar International Consultants) (2015). 'Myanmar Energy Master Plan: Consultants' Report'. ADB Project: TA 8356-MYA. Mandaluyong City: ADB and MMOE. Available at: https://www.adb.org/projects/documents/mya-46389-001-tacr-2 (accessed 7 January 2021).

Attigah, B., and L. Mayer-Tasch (2013). 'The Impact of Electricity Access on Economic Development: A Literature Review', in L. Mayer-Tasch, M. Mukherjee, and M. Reiche (eds), *Productive Use of Energy—PRODUSE: Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa.*

Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Available at: www.esmap.org/sites/esmap.org/files/ESMAP_GIZ_BMZ_AEI_PRODUSE_Study_FullText_Optimized_0.pdf (accessed 7 January 2021).

Aung Kaung Set (2018). 'A Study on Electricity Generation Development in Myanmar'. Unpublished Master's thesis. Yangon: Department of Economics, Yangon University of Economics.

Bee, E.R. (2016). 'The Influence of the Electric Supply Industry on Economic Growth in Less Developed Countries'. Doctoral dissertation. Hattiesburg, MS: University of Southern Mississippi. Available at: https://aquila.usm.edu/dissertations/379 (accessed 7 January 2021).

Berkel, H., M. Cardona, H. Hansen, J. Rand, P. Castro Rodriguez, N. Trifković, E. de Witte, H. Zille, K. Swe Latt, and F. Tarp (2018). *Myanmar Micro, Small, and Medium Enterprise Survey 2017: Descriptive Report*. Helsinki: UNU-WIDER, Copenhagen: University of Copenhagen, and Nay Pyi Taw: Central Statistical Organization. Available at: https://www.wider.unu.edu/sites/default/files/Publications/Report/PDF/Myanmar-MSME-survey-2017.pdf (accessed 7 January 2021).

Bloomberg NEF (2020). 'Climatescope2020: Myanmar'. Available at: https://global-climatescope.org/results/mm (accessed 5 January 2021).

Bulmer-Thomas, V., (1982). *Input-Output Analysis in Developing Countries: Sources, Methods and Applications*. Milton, Queensland: John Wiley & Sons Australia Limited.

Consult-Myanmar (2017). 'Myanmar Opens First Biomass Power Plant'. 3 April. Available at: https://consult-myanmar.com/2017/04/03/myanmar-opens-first-biomass-power-plant (accessed 15 August 2020).

EIA (2020). *Capital Cost and Performance Characteristic Estimates for Utility Scale Electric Power Generating Technologies*. Washington, DC: EIA. Available at: https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2020.pdf (accessed 7 January 2021).

EuroCham Myanmar (European Chamber of Commerce in Myanmar) (2019). *Energy Guide 2019*. Yangon: EuroCham Myanmar. Available at: https://eurocham-myanmar.org/uploads/460d5-energy-guide-2019-web-.pdf (accessed 27 December 2020).

Frontier Myanmar (2020). 'The Scramble for Solar: Inside 2020's Most Controversial Tender'. 22 September. Available at: https://www.frontiermyanmar.net/en/the-scramble-for-solar-inside-2020s-most-controversial-tender (accessed 27 December 2020).

Hansen, H., B. Sørensen, S. McGill, B. Gibertini, N. Trifković, J. Rand, F. Tarp, San Myint, Than Zaw, Khin Moe Moe, Phyu Pyar Tun, and Myo Htut Aung (2020). *Myanmar Micro, Small And Medium Enterprise Survey 2019: Descriptive Report*. Helsinki: UNU-WIDER, Copenhagen: University of Copenhagen, and Nay Pyi Taw: Central Statistical Organization. Available at: https://www.wider.unu.edu/sites/default/files/Publications/Report/PDF/Myanmar-MSME-2019.pdf (accessed 7 January 2021).

Hartono, D., S.H. Hastuti, A. Halimatussadiah, A. Saraswati, A.F. Mita, and V. Indriani (2020). 'Comparing the Impacts of Fossil and Renewable Energy Investments in Indonesia: A Simple General Equilibrium Analysis'. *Heliyon*, 6(6): E04120. https://doi.org/10.1016/j.heliyon.2020.e04120

The Irrawaddy (2019). 'Myanmar's First Solar Power Plant Joins National Grid'. 28 June. Available at: https://www.irrawaddy.com/news/burma/myanmars-first-solar-power-plant-joins-national-grid.html (accessed 27 August 2020).

Kapsos, S. (2005). 'The Employment Intensity of Growth: Trends and Macroeconomic Determinants'. Employment Strategy Paper 2005/12. Geneva: Employment Trends Unit, Employment Strategy Department. Available at: https://www.ilo.org/empelm/pubs/WCMS_143163/lang--en/index.htm (accessed 7 January 2021).

Khine Nyein, K. (2020). 'Potential Impacts of Electricity Shortages and Price Increases'. Background work for a SAM multiplier analysis paper, unpublished report. Nay Pyi Taw: Central Statistical Organization.

Miller, R.E., and P.D. Blair (2009). *Input–Output Analysis, Foundations and Extensions*. New York: Cambridge University Press. https://doi.org/10.1017/CBO9780511626982

MMSIS (Myanmar Statistical Information Service) (2020a). 'Statistical Data: Electric Power Generation and Sales'. Available at: http://mmsis.gov.mm/statHtml/statHtml.do?orgId=195&tblId=DT_MAB_0001&conn_path=I2 (accessed 10 January 2021).

MMSIS (2020b). 'Statistical Data: Electric Power Installation, Generation and Consumption'. Available at: http://mmsis.gov.mm/statHtml/statHtml.do?orgId=195&tblId=DT_YAG_0006&conn_path=I2 (accessed 7 January 2021).

MMSIS (ongoing). 'Myanmar Statistical Information Service'. Available at: http://mmsis.gov.mm (accessed on multiple dates).

MOEE (2014). 'Electricity Rates for 2014'. Unpublished report. Nay Pyi Taw: MOEE.

MOEE (2019a). 'Electricity Demand Forecast'. Unpublished report. Nay Pyi Taw: MOEE.

MOEE (2019b). 'Electricity Utilization Survey'. Unpublished report. Nay Pyi Taw: MOEE

MOEE (2020a). 'History of MOEE'. Available at: https://www.moee.gov.mm/en/ignite/page/3 (accessed 7 January 2021).

MOEE (2020b). 'Unit Calculator'. Available at: https://www.moee.gov.mm/en/ignite/page/640 (accessed 7 January 2021).

Hein, Z., and M.M Aung (2020). 'Biofuel Plants to Help City's Waste Woes'. *Myanmar Times*, 31 January. Available at: https://www.mmtimes.com/news/biofuel-plants-help-citys-waste-woes.html (accessed 20 July 2020).

Robertson, B., and M.S. Taung (2015). *Industrial Zones in Myanmar: Diagnostic Review and Policy Recommendations*. Yangon: Friedrich Naumann Foundation for Freedom.

Stern, D.I., P.J. Burke, and S.B. Bruns (2016). 'The Impact of Electricity on Economic Development: A Macroeconomic Perspective', EEG (Energy and Economic Growth) State-of-Knowledge Paper 1.1. Oxford: Oxford Policy Management.

Taliotis, C., E. Giannakis, M. Karmellos, N. Fylaktos, and T. Zachariadis (2020). 'Estimating the Economy-Wide Impacts of Energy Policies in Cyprus'. *Energy Strategy Reviews*, 29: 100495. https://doi.org/10.1016/j.esr.2020.100495

Tuorila, K. (2020). 'Myanmar and Its Energy Sector in Fast Forward Transition'. Asian Insiders, 14 April. Available at: https://asianinsiders.com/myanmar-and-its-energy-sector-in-fast-forward-transition (accessed 16 August 2020).

Van Seventer, D., F. Tarp, N. Nyo San, S. Thie Nu Htwe, and Than Dar (2020a). 'A 2017 Social Accounting Matrix for Myanmar'. WIDER Working Paper 2020/66. Helsinki: UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2020/823-8

Van Seventer, D., F. Tarp, K. Ohnmar Myi Thein, S. Thie Nu Htwe, and N. Tai (2020b). 'Structural Features of the Myanmar Economy through the Lens of a 2017 Social Accounting Matrix'. WIDER Working Paper 2020/71. Helsinki: UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2020/828-3