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Power Industry Disruptors and Prospects of the Electricity Demand in the Greater Metro-Manila Area

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Abstract

The power industry is being severely disrupted globally and local industry stakeholders have every reason to be worried. The question is how stakeholder capital should henceforth be deployed to reduce the risk of stranded assets. This study is undertaken to assess the impact of power industry disruptors on the near-term prospect of the electricity demand in the most important submarket of the Philippine power market, the greater Metro-Manila area. The emphasis is on the impact of technology disruptors, especially of solar photovoltaic generation and storage, on top of and in conjunction with policy disruptors. Part One tackles firstly the risks to sustained economic and income growth which will, in turn, impact on the demand for electricity—the macro-economic risks, the global risks, and the policy risks; secondly the risks internal to the electricity industry itself—the technology disruptors especially coming from growing adoption of rooftop and mini-grid solar photovoltaic installations and battery storage. The challenge of solar distributed generation counsels a more sober outlook and a more inclusive portfolio diversification by centralized power generation capitalists. Part Two employs an error correction model to forecast the growth of aggregate and disaggregate (by customer types) demand in a distribution utility franchise, in this case, the Meralco franchise, over the next five years. This model can be adopted as benchmark and adapted by industry stakeholders especially other distribution utility franchises for their own forecasts which should inform the rate setting exercise between the distribution utilities and the regulator, the Energy Regulatory Commission.

JEL Classification: C53, Q47, Q43

Key words: Electricity demand, Forecast methods, Distributed Solar Photovoltaic, Rooftop and Mini-grid systems, Policy disruptors

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Part 1

1. Macroeconomic Risks to Philippine Growth

Introduction

The Greater Metro-Manila electricity market is the largest and the most dynamic electricity submarket in the Philippines. Meralco, which covers this submarket as its franchise area, accounts for about 55% of total electricity sales in the country. The correlation coefficient between Meralco sales and PHL GDP is 0.97. How electricity is delivered and at what price in this submarket has a disproportionate impact on the economic prospect of the whole Philippine economy. And disruptors of the power industry will have the most impact in this area. Already, the familiar regulated franchise model is being slowly dismantled. The prospect of electricity demand for the whole Philippines to 2040 has been studied by Danao and Ducanes (2018). Sometimes to get the measure of the whole, it is very helpful to get the measure of its most prominent subpart where a sneeze translates into a fever elsewhere.

Old versus New Normal Growth

The one bright spot for the Philippines in the second decade of the 21st century is its rapid growth—the average growth rate of GDP in the last six years was 6.5%, which exceeded the 4.8% average growth under the Arroyo administration and the 4% average growth in the decades before that. This was thus welcomed as possibly the 'new normal'. The Duterte administration aims to maintain or even exceed this new normal. The first full year of the Duterte administration managed a 6.7% GDP growth, which exceeded the 6.5% norm. An average growth of 7% seemed doable. But 2018 has a mixed message: the 6% GDP growth in 2018 Q2 was a three-year low and has renewed the conversation of a revert to the old norm. Not that the 6% growth is to be sneezed at but because by mid-2018 the dark clouds have started to gather. The inflation rate spiked in mid-2018, though definitely cooling off (5.2% in Q4 2018), and the BSP's gradual raising interest rate can hamstring growth (see also, Fabella, 2018a).

The Philippine GDP grew at 6.2 % for 2018 well below the 2017 growth of 6.7% and below as well the new normal standard of 6.5%. Given the draught and crop damage, the looming fallout from ENDO and the still unknown hit on DFIs from TRAIN2, we will be lucky to grow at the same pace in 2019. Firms may prefer to batten their hatches in 2019-2021 waiting for sunnier days.

More worrisome is that Manufacturing grew at 4.9% while Services grew at 6.6% during the full year 2018. In other words, Services drove GDP growth in the second full year of the Duterte administration. This worrying trend started in the second half of 2018! The new normal era trend of Manufacturing driving GDP growth is over. When Manufacturing grows at a faster rate than Services, growth in low-income countries tends to be inclusive (Daway et al., 2017). And more inclusive growth tends to be more sustained (Berg and Ostry, 2011).

One can easily fall for the temptation to consider the recent past as the permanent norm. But we have had in our past episodes of rapid growth that became aborted: the debt-financed rapid growth in the second half of the 1970s under President Marcos expired in the early 1980s; and rapid growth in the Ramos watch in the mid-1990s skidded in the Asian Financial Crisis. Our economic history in the second half of the 20th century was characterized by a boom-bust cycle that counsels sobriety. The Duterte Administration is trying to extricate the Philippine economy from a revert to the old normal. On the one count of quality growth, this seems to have failed. The closing of the infrastructure gap is still in the future. Aside from internal macroeconomic minefields, there are global risks. Sustainability of the new normal is the holy grail of development.

Global Risks

While robust global growth pulls up country's growth, a global slowdown pulls down individual country's prospects. The judgment of prognosticators is that the global economy has entered into a more perilous, less predictable world. Global growth is predicted to slow down; Goldman-Sachs (Economic Outlook 2019) reduced its forecast from 3.8% in 2018 to 3.5% in 2019. IMF lowers its global growth forecast for 2019: 3.7% down 0.2 from April forecast. The FED monetary tightening in USA had a knock-on effect of monetary tightening in the Philippines, reinforcing the BSP response to domestic price uptick—car sales in 2018, for example, partly due to higher interest rate.

Trade War

The Trump-initiated trade war is center stage and threatens to hurt every country in the world. Will it escalate further exacerbating the global growth slowdown? It is anybody's guess. The slow growth of the global economy will impact on the growth prospects of the Philippines. First, this will slow down global export growth with a negative knock-on effect on the appetite of developed countries to bankroll foreign investment. Of the smaller foreign investment flow, there will be a reallocation by destination—there will be a trade and foreign investment diversion away from PRC and other areas towards the ASEAN whose share of the smaller flow may rise due to the perception of overall stability. Who in the ASEAN will benefit? Vietnam first comes to mind, then Thailand, and Indonesia; only then does the Philippines come to mind. But even this small positive diversion to the Philippines may raise the total foreign investment in the country due to a small base.

Global Petroleum Price

How will the global fuel price behave in near term? Perhaps in medium term the average will be no higher than \$70/barrel. This is important because already the Philippines trade deficit is rising and the balance of payments (BOP) has turned negative, leading to the reduction in foreign reserves. Fracking has begun to crack again and that will put an upward ceiling on price regardless, it seems, of what OPEC and allies such as Russia will do. The recent reduction has resulted in the reduction in the pump price of gasoline which, no doubt, has partly resulted in the steadying of core inflation in November 2018.

The COP24 Katowice Agreement

Though rendered less ambitious and still lacking a toothed enforcement mechanism, beyond naming and shaming remains a breakthrough as the ‘rulebook’ that will deliver on the Paris Agreement starting in 2020 (McGrath, 16 Dec 2018, BBC News). The Philippines pledged a 70% reduction in its carbon emission. How will that translate into policies in the country? There will be more tail wind for and easier passage of incentives-granting proposals to advance renewables as well as to distributive generation, especially to the solar PV (photovoltaic) rooftop installations and net metering. This will prospectively attenuate the retail business of distribution utilities. This, in turn, will make financing of extensions to distribution assets more challenging (more on this in Section 2 below). If, on the other hand, the response by the Philippine government is the deployment of more EVs among public conveyances and incentives to EVs for private use, which is the correct response since 36% of our carbon emission is from transport, this will likely boost the retail business of distribution utilities and reduce that of oil companies.

BREXIT and All That

How the British divorce from the European Union (EU) will play out will affect the EU and the global economy. ‘No deal’ outcome is the worst, as the two parties reset their trading relations to WTO standard. Both parties will experience output dampening as the process unfolds. At the moment, the no deal outcomes is the most likely, as the different sides in the British Brexit debate seem determined to have their own way in the ‘game of chicken’ (the ‘game of chicken’ in game theory with all super rational players usually ends up in disaster). The Brexit turmoil will redirect investment from Europe to East Asia less PRC. But the global growth will slow further and exports to EU will step back.

TRAIN2

TRAIN1 enacted and signed into law in 01 January 2018 was designed to bankroll the BUILD x3 program of government. Its expected side effect, inflation, was unfortunately compounded by price pressure from global oil price spike from $40 to %70/barrel, from the unfortunate mishandling of the rice supply by NFA and from the basic food supply disruptions due to inclement weather. On the whole, TRAIN1 is one signal success of the Duterte government which also gave comfort to the business sector by refusing to postpone the mandated fuel excise tax increase in January 2019. How much of the extra revenue realized will finance infrastructure build-up remains to be seen as populist claims on fiscal resources are also ramping up and heeded by the authorities.

TRAIN2, which is expected to pass in the first quarter of 2019, has unique challenges to our capacity to attract DFIs. The Philippine investment rate at about 20% over the last 25 years is dismal. TRAIN2 is wholly an investment play: reduce CIT from 30% to 20% (TRABAHO version) to fire up the domestic entrepreneurial spirit with higher net returns. This will, however, leave a Php30 billion hole in the fiscal balance sheet per 1% drop in CIT rate. To plug the hole, it proposes to lift fiscal incentives that in the DOF’s judgment have become stale and overstaying. Prominent among these is the replacement of the gross income tax of 5% imposed on, and strongly opposed, by foreign investors in PEZA. The DOF estimates that PEZA locators effectively pay the CIT equivalent of 13% versus the 30% CIT paid by non-

PEZA firms. The replacement of GIT by CIT may result in reduced DFI interest in the Philippine location just when the PEZA strategy is beginning to reap success. It is also this increased volume of foreign investment in PEZA that partly propelled the Manufacturing growth in the new normal era. And just as the global reallocation of foreign investment due to global rebalancing and trade frictions is about to happen. There is reason to believe that tradables and exports—of which most PEZA DFIs are into—should be treated differently, since they operate in a different environment. TRAIN2 framers hope that it will raise the overall investment rate; but that remains a hope. In more perilous times, one stays with what worked.

Trade, BOP and Fiscal Outlook

BUILDx3 has fueled the expected import boom—especially in equipment—and, together with higher oil import bill and slower export growth, has widened the trade deficit. In conjunction with slowing OFW remittance growth, these have led to a rising BOP deficit, which is worrying, since the Philippines has become, on average, a BOP surplus country since 2002. The government is also trying its utmost to reign in the fiscal deficit to close to 3% of GDP but the political and populist imperatives (for example, as shown the free tuition for SUCs and in the recent road users tax controversy where the lower house wanted the road users fund to be disbursed) pushing the opposite way may weaken its resolve. The pressure for populist programs and projects will only rise in the near term. The fiscal authorities have also to face up to unfunded contingent liabilities, such as the GSIS and the armed forces pension fund and the universal health care program. The fiscal balance can turn south quickly, drive credit ratings south and put into question the funding of the BUILD x3 program.

Populist Policy Risks

ENDO (End of Contractualization): This will continue to bite in the near term. HB 6908 or 'An Act Strengthening the Security of Tenure of Workers' was approved on third reading by the Lower House in January 2018 and certified urgent by President Duterte in September 2018. Regularization of non-regular workers will mean higher labor cost and fewer employed workers. By PSA (Philippine Statistics Authority) survey data of firms with 20 plus workers (ISLE 2014), about 30% of construction workers, 22% of Manufacturing workers, and 10% of retail trade workers are non-regulars. PLDT and SM are locked in a legal dispute with DOLE about the treatment of their non-regulars. This is a labor cost minefield. This will retard investment even as it raises open unemployment. Contractualization has been painted as evil by opponents but, although sometimes abused, has its virtues. Contract work can be beneficial as 'labor sharing': scarce employment opportunities are being shared by more workers; permanent workforce are paid less than they would be without labor sharing; and contractual workforce realize some income, however sporadic, instead of none at all. Work attitude and work aptitude decay much faster among the long-term unemployed than among those with sporadic spells of employment. If HB 6908 becomes law, fewer workers will be employed and many workers now currently listed as underemployed will become openly unemployed. Businesses will invest in labor-saving machines—more smart ATMs to replace bank tellers. Investment will locate in businesses where labor cost can be passed on. In any case, it will raise the cost doing business and may damp down investment. The hit on Manufacturing will be more severe than on Services, since Manufacturing cannot pass on the higher labor cost to consumers, which Services as a group can. Thus it will drag down Manufacturing which the Duterte administration is trying to make the engine of growth (Fabella, 2018c).

Cha-Cha and Federalism

Among the factors that murky the investment climate in the Philippines in the near term is the proposal for a charter change towards Federalism. The contemplated shift to a Federalist state continues to have loud and prominent advocates, which include President Duterte. The cost of such a shift depends upon the structure that the federalist state has chosen. The three competing versions on offer are the Consultative Committees version, the PDP-Laban version, and the so-called Arroyo version passed on second reading by the Lower House on 04 December 2018. Whatever version will pass muster, a cloud of uncertainty will form over the Philippine investment space and will delay many contemplated investment projects perhaps for a few years as we wrestle with new realities. Beyond the cost consideration and beyond gratuitous claims and counterclaims, there is just no hard evidence that Federalism will improve governance or inclusion outcomes (Fabella and Daway-Ducanes, 2018). We may be jumping from the frying pan to the fire.

To conclude this section, there are many minefields that can come in the way of a smooth sustained macroeconomic growth which will impact the growth of demand for power in the Meralco franchise area. The sustainability of rapid economic growth of last half dozen years is facing many headwinds in the near term. There is no place for 'irrational exuberance'.

2. Microeconomic Attenuators of Retail and Wire Business of Distribution Utilities

Previous Policy Disruptors

In the Philippines, the first two decades of the 21st century witnessed many disruptors in the power sector that could hardly have been predicted from the remote past. Many of these are policy-based disruptions. We have experienced the unbundling of the major segments (distribution, transmission and generation) of the power sector through EPIRA (2001). EPIRA has rendered the electricity market contestable through RCOA, which effectively unbundles the regulatory model of distribution through franchise into the wires and retail business. With the retail business being effectively liberalized, we have seen a greater emphasis on the environmental impacts of the fuel mix because of global warming concerns which spawned the Renewable Energy Act which, in turn, hastened the growth of the renewable power generation through incentives, such as feed-in tariff and merit order dispatch, as well as the 'renewable portfolio standard'.

Few of these policy changes could have been predicted from the past as business-as-usual outcomes of the past. Where their existence was known from the adoption by more advanced countries, the risks associated with them are compounded by the vagaries associated with the politics of their adoption and implementation.

Market Contestability and Retail Competition and Open Access (RCOA)

RCOA is really an attenuator of the regulatory franchise model of power industry. It implies that the DU franchise is *effectively unbundled* into: (a) wires business, and (b) retail business. With a full-fledged RCOA (as in New Zealand, see Fabella et al., 2018), the legal franchise no longer holds for the retail business, since RCOA allows others retailers (RESs) to sell power in the DUs' franchise area. Exclusive privilege now only holds for the wires business. In the past, exclusivity in the retail business was viewed as the financial warranty for the financing of the distribution wires. The captive market shrinks as the contestable market share rises in the franchise. This has implication for the financing of wires expansion—more risk associated means higher interest rate of borrowing and, thus, higher distribution fee in the franchise. If the wires fees are inflexible, it could mean higher fees for captive consumers. Fortunately, whether captured or contestable, power still has to flow through the imbedded wires and with appropriate and flexible fee structure, the viability of the wires business can still be assured. At the moment, RCOA is still stuck in the 1 MGW and over range because of legal hurdles; but that is not a long-term state of affairs. At the moment, only very large establishments are shifting to RES. On the whole, the problem posed by RCOA is adjustment to the wires business and inflexibility. It is not an attenuator of the electricity consumption, per se, but an attenuator of the retail business of the DU.

Technology Disruptors: Appliance Efficiency

Energy efficient appliances will become the dominant purchases of household gadgetry. Most importantly are LED (light emitting diodes) light bulbs which have lifespan 25 times longer than incandescents using much less wattage per lumen of illumination (200 lumens per watt or about 80% less than incandescents). Though with higher upfront if rapidly falling cost, the savings can be considerable over its lifetime (up to 75%). The LED lamp market is expected to grow at a compound annual rate of 25% in the USA from $2 billion in 2014 to $25 billion in 2023 (Bergesen et al., 2016). In Southeast Asia, the LED market grew about 63% year-on-year between 2013 to 2015. Energy-efficient appliances (air conditioners, refrigerators, dryers, dishwashers, etc.) are also on the move with energy reduction of 10-50%. For example, energy efficient refrigerators now use up to 40% less energy than conventional models bought in 2001. This will reduce overall demand for electricity, which will strand the more costly generation assets. Already, Therma Mobile, a subsidiary of Aboitiz Power Corp., has announced the mothballing of its bunker C-fired power barges due to lack of power supply agreements (Rosales, 2019). The power barges are effectively stranded by developments in the market such as the growing adequacy of lower cost and more stable power supply. Appliance efficiency advances have been in the cards all along and does not constitute a surprise for power industry stakeholders.

Technology Disruptors: Renewables

The more potent threat to industry stakeholders is the emergence of distributed generation which became viable first in the West because of rapid technical innovations and second, because of the generous incentives for Distributed Energy Resources (DERs).

Distributed Energy Resources (DER)

DER has been growing rapidly and explosively, going forward in the West. Zion Market Research estimates (March 2018) that the distributed energy market will reach US$103 billion in 2023 up from US$57 billion in 2017 at a compound growth rate growth of 10.3% per year. The two types are off-grid and on-grid with the latter leading the way. On-grid solar PVs supply local demands and also replace power from the grid. By sources, DERs come either as fuel cell, micro-turbines, wind turbines, reciprocating engines and solar PVs. Distributed Solar PV generation leads the pack accounting for 21% of total in 2017 and is expected to grow even faster than the whole at 16.9% to 2023. Asia Pacific with 40% share dominated the market for distributed power generation. Incentives granted to adopters of distributed PV and greater awareness among energy consumers of the cost of greenhouse gas emission concerns and the rapid fall in the cost of solar panels and the PV systems have fueled the growth of the DER market. Residential solar installations grew 66% between 2014 and 2015 alone in the USA, ensuring that 30% of all new generation capacity was solar (Muro and Saha, 2016). The cost per kWh of solar PV electricity has gone down 80% from five years ago. Sub-5 cent per kWh has been attained and will only go lower if at a slower pace.

At the moment the share of PV-type DER in the Philippine power market is minuscule. It was no different in the USA and EU fifteen years ago. In those localities, advances in technology leading to drastic fall in up-front investment and incentives from the government have combined to produce explosive—usually non-linear—growth. The adoption of rooftop solar PV follows the diffusion architecture of epidemics (Graziano and Gillingham, 2014). The last ten years may be the incubation stage when the information is just slowly being digested and templates are few and far between. That could change quickly.

Advances in Solar Photovoltaics

1. Installed Capacity Trajectory

The growth of the installed capacity of solar PV has been exponential. As observed it is expected to grow at about 17% every year from 2017 to 2023. **Figure 1a** below shows the cumulative solar PV capacity growth in the decade from 2006 to 2015. **Figure 1b** shows the trajectory of actual solar energy capacity (red) versus predictions (other colors). The takeaway is that the growth of solar PV capacity has bested even the most optimistic predictions (Greenpeace). The dynamics has been exponential rather than a linear one. This trajectory is expected to continue in the near foreseeable future.

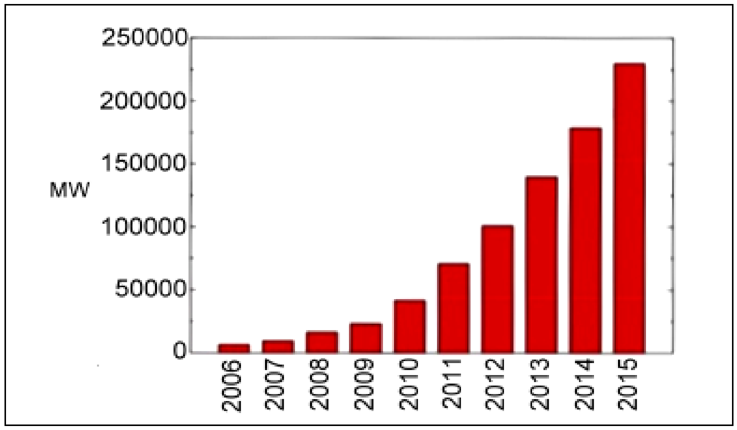


Figure 1a. *Slide Source: "A Eureka for Solar Energy," Lecture by Conings, 2017*

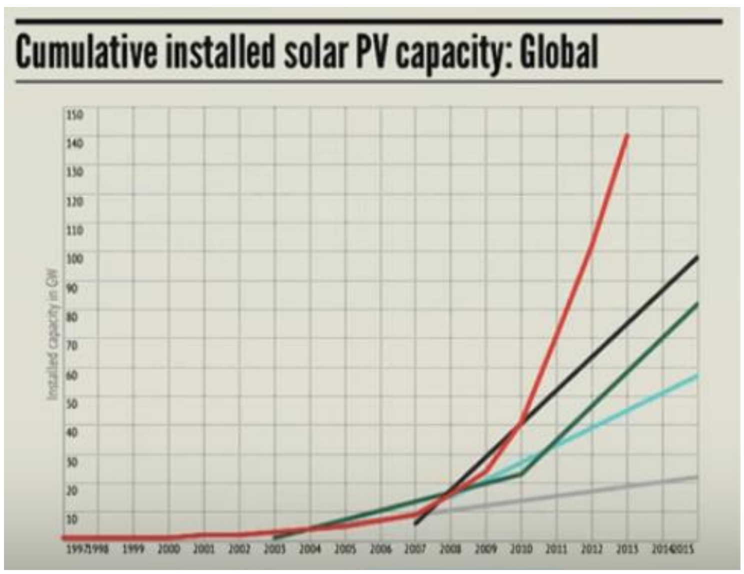
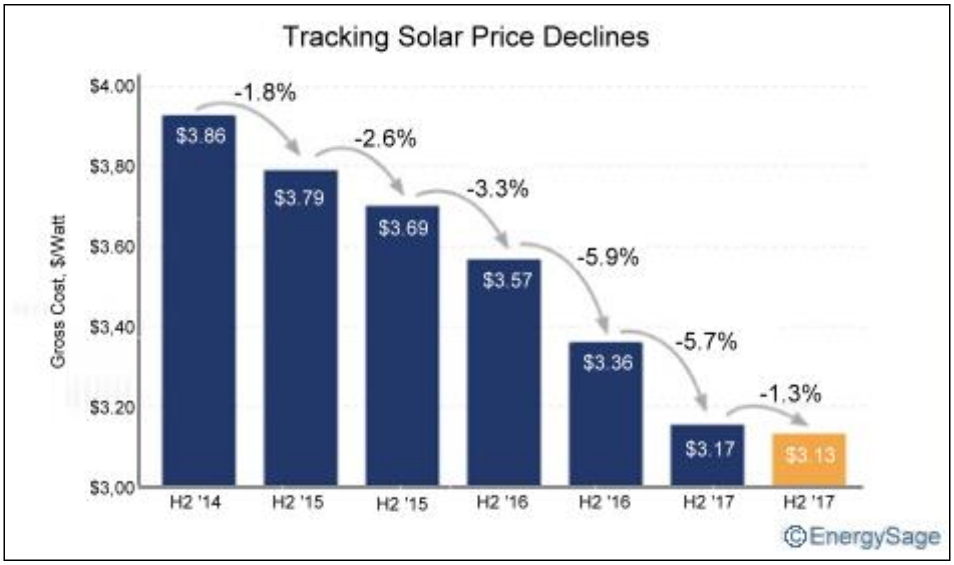


Figure 1b. *Slide Source: "Photovoltaic Solar Energy," Lecture by Henry Snaith, 2017*

Figure 1. Global cumulative installed capacity versus predictions

2. Solar Panel Cost Trajectory

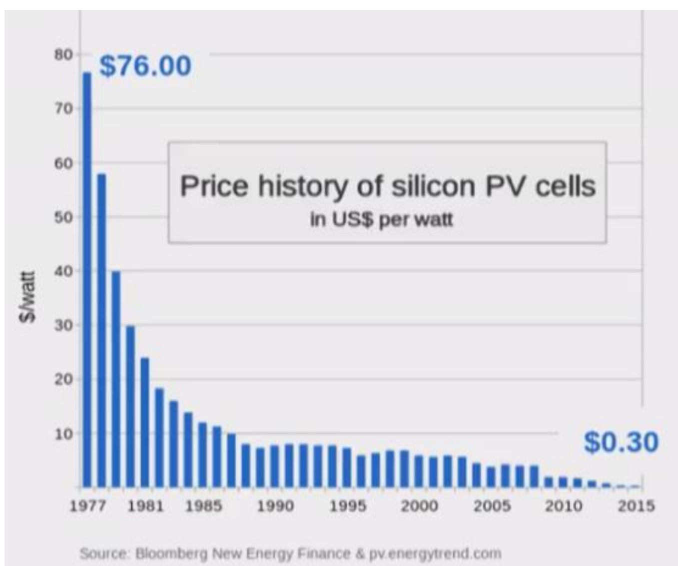
Between 2014 and 2017, the reduction in the cost of solar panels was dramatic (**Figure 2** below). We expect this to continue as production and demand for solar panels gets ramped up and technical advances cumulate.



Source: EnergySage

Figure 2. Solar panel cost over time

These gains in cost per panel translate into a radical decline in cost per watt, as shown in **Figure 3**. Sub-5 cent will become the norm is areas with solar resources-abundant areas of the world around the equator. In the recently concluded auction for PV installation in Dubai, the winning bid was $0.02.4 per kWh while the average going rate for coal is $4.6/kWh.



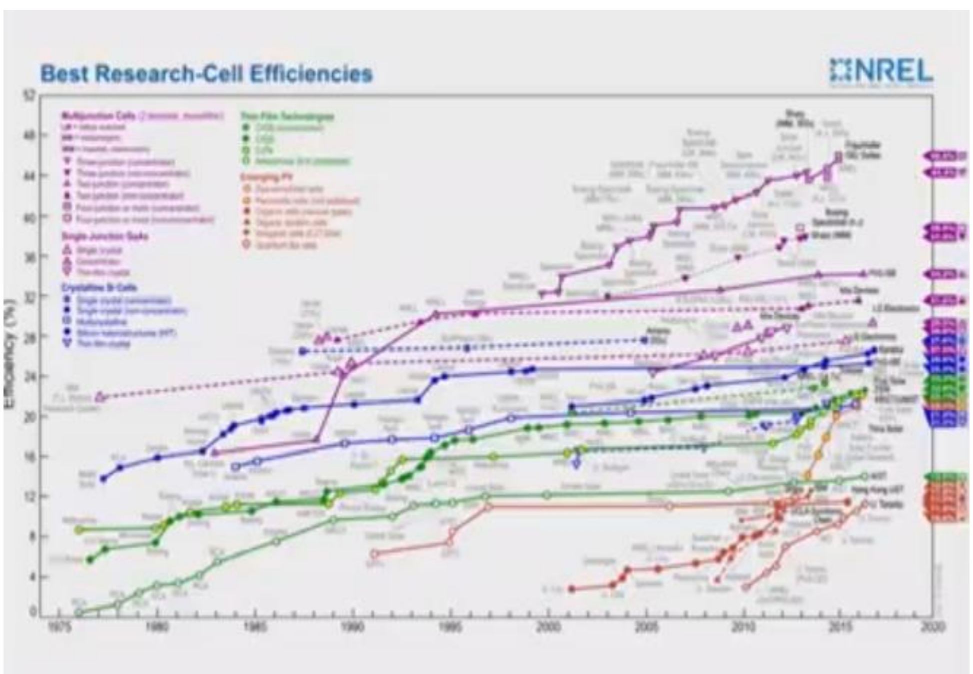
Source: "Photovoltaic solar energy," – Kavli Lecture by Prof. Henry Snaith

Figure 3. Price trajectory of solar power per watt, 1977 to 2015.

Technical Efficiency of Solar Cells and Batteries

The utilization of solar energy comes via solar cells. The percentage of the solar radiation transformed into electricity defines the efficiency of a solar cell. At the moment, these are mostly done through silicon/cobalt oxide-based solar cells but other candidates are fast nibbling on its heels. Zinc bromide with gel promises as a candidate to replace silicon. Likewise, aluminum-based batteries are poised to challenge the front runner. While the 21.5% efficiency solar cells is the current commercial leader (Sunpower SPR-X21-345 offered by E. Musk's *Solar City*), that performance will be in the rearview mirror soon. Higher efficiency panels are now available (like gallium-arsenide panels) but the costs are also higher. It is now the capitalistic profit motive that is fuelling the race for the pot of gold at the end of the photovoltaic rainbow.

The race here is three ways: for the composition of the cathode, that of the anode, and that of the electrolyte that transmits the ions. In the cathode front, lithium-ion leads the way in renewable battery technology, but more promise comes with lead- or tin-based *perovskite* (calcium titanium oxide) especially when stacked with lithium; and even farther down the line the liquid metal magnesium-antimony combine has even more ambitious promise. In the cathode front graphite is standard but more promising graphite, graphene say, are in the running. The promise is here is in flash recharging and industrial size storage capable of stabilizing grid-level supply. In the electrolyte front, solid electrolyte, say, non-combustible ceramics, is challenging liquid electrolytes which are flammable. For the moment, cost and scale considerations favor lithium-based battery. Tesla's massive 100-megawatt battery installation in South Australia is now an operational success; it has lowered cost and vanished blackouts in the area. The mad rush to battery storage dominance is captured by **Figure 4** where lithium ion batteries are in blue around the middle of the range. Much greater efficiencies are being attained but are still barred from commercial deployment by cost consideration.



Source: "Photovoltaic solar energy," – Kavli Lecture by Professor Henry Snaith

Figure 4. Mad rush for solar battery supremacy.

Types of PV Installation

PV generation could either be (a) autarkic or off-grid: production is wholly consumed by the household, or (b) open system that is on-grid and net metered: PV production is partly consumed locally and when in excess (deficit) is exported to (imported from) the grid. Off-grid solar PVs may be favored in the Philippines due to its archipelagic geography—many distribution utilities are unconnected with the grid and may actually be still served by bunker fuel-driven generation. It is the growth of rooftop on-grid solar PVs that is the concern of grid-connected DUs like Meralco.

Net metering is the most ubiquitous of the distributed solar PV generation. The reason is that battery set-up totally changes the cost. The big debate over net metering in the USA asked the question: Does net metering shift the cost of power from adoptors to non-adopters? The growing consensus is that net metering benefits all ratepayers, adoptors and non-adoptors alike, *when all costs are taken into account*—avoided costs of additional power assets to meet peak demand, fewer upgrades to the grid, less carbon emission, displacement of more costly fossil fuel, the promotion of energy security, the reckoning over the lifetime of the solar assets not just a one-off, the use of 'Value of Solar' (VOST) methods. Many of these factors are neglected in static one-off reckoning of net metering (Muro and Saha, 2016).

Rooftop Solar PV systems and Distribution Utilities (DUs)

Rooftop Distribution PV systems pose special problems for distribution utilities (DUs):

a. DUs have to provide wire capacity adequate for peak market consumption, not for average consumption for a period or for consumption of just their own retail business;

b. PV adoptors lower the utilization of distribution wires and raise the average fees for adoptors and non-adoptors alike without the changes in fee structure;

c. PV adoptors lower the utilization of NGCP (National Grid Corporation of the Philippines) transmission grid so transmission fees will need to rise;

d. Previously lifeline rate subsidizers who become PV adoptors may fall below the lifeline cut-off and join the ranks of the subsidized, thus, increasing the lifeline subsidy fees;

e. There may be a difference in the price (lower) that the DU procure from open market (WESM) and the mandated blended price (higher) from PV surplus exporters.

The proposal of DOE to finance lifeline and other universal missionary fees from the treasury is welcome but will it come to pass when there is an increasing pressure on the budget deficit front?

Solar PV system Classification and Features

Solar PV system can either be:

1. Residential: According to Graziano and Gillingham (2014), adoption among residential customers is strongest among single detached dwelling units with available space and lags among households in high-rise multi-dwelling units due to common resource problems. In the Philippines and in the Meralco franchise area, the share of single detached dwellings will shrink rapidly as high-rise apartment dwellings become the preferred affordable dwelling in the near term. Likewise, Graziano and Gillingham (2014) observe that adoption among the very affluent is slow presumably because the savings are not very attractive to high equity households. It is the middle class that are attracted to PVs for the savings they afford. But the middle class in the Meralco franchise area is still narrow; likewise, the net metering PV costing the equivalent of a small car purchase (500Ks) and a payback period of 7-9 years remains too high for many. Mini-grids can however serve multiple households in high rise buildings or a gated community and can be managed by community/subdivision counsels.

   The diffusion experience seen, say, in Connecticut where single detached units with large horizontal spaces abounded will not be as rapid here where the high-rise multiple dwellings have become the dominant dwelling of choice today and in the near term.

2. Commercial and industrial: The share of commercial and industrial demand in total sales of the DU enhances the efficiency of DUs (Fabella et al, 2018). As PV technology improves, we can expect the solar PV adoption by commercial and industrial establishments to escalate, since (a) franchise consumers are more cost- and competitiveness-conscious; (b) they have wherewithal to in-house or bank-finance PV systems; and (c) payback period for PV investment shortens with the rise in consumption.

The lesson to be learned here is that rooftop solar PV systems will lead to the attenuation of the DU franchise, that is, increasingly limited only to its wires business. Rooftop solar PVs can not only attenuate the retail business of DUs but also complicate its wires business due to the two-way flow of power (import and export of power) and the associated exchange rate to govern the trade. This latter can be obscured by political considerations independent of efficiency.

How have some traditional incumbent power players responded to the threat of stranded assets? E.ON, a traditional German gas and electricity giant acquired the renewable energy utility company Innogy in 2018 and will henceforth pour considerable resources into renewables. Norway’s oil and gas giant Statoil (now Equinor) is staking $12 billion in major renewable projects especially offshore windfarms, floating windfarms and large scale storage for marine systems. Rather than resist the renewables tsunami, incumbents and traditional power stakeholders are seeking opportunities and riding the tide.

Summary

The next five years will be very challenging for DUs built on the regulatory (franchise) model of the power industry. With respect to their markets in the Philippines, there are reasons to believe that the macroeconomic environment will be more perilous and volatile. The ongoing Trump-initiated trade war may escalate and further weaken the softening global economy. This will soften the global market demand for everything including power and the export and the investment market will follow suit. The global fuel price is still unsettled but we think that it will converge to somewhere in the $70/barrel range in the near term. There are many internal economic reasons for worry: the ENDO will surely affect the labor cost with tradable goods sector getting the heavier burden in the medium term. The interest rate hikes occasioned by the inflationary spike in the second half of 2018 will dampen spending in the coming years. We think that inflation itself will however head back to within the target band of the BSP, especially with the softening of oil price. But TRAIN2 adds to the uncertainty as it struggles to replace the old overstaying incentives system with the new and fairer system. One proposal is to replace gross income tax rate at 5% by the CIT rate of eventually 20% among the PEZA locators. Most PEZA locators are of the tradable genre and beg to be treated differently from non-tradables (see e.g., Fabella, 2018b). 'Fair' may mean differential treatment rather than equal treatment. Furthermore, here are risks associated with political projects: the shift to Federalism movement makes the regulatory environment more inscrutable and will lead to a wait-and-see attitude among investors. There are fiscal minefields such as the impending pension shortfall in the face of growing populist sentiment among policymakers.

In the microeconomic front, developments will emerge to attenuate the regulatory model and will effectively unbundle the DU franchise business into the retail and the wires business. RCOA chops up the franchise area consumers into captured and contestable. The RCOA allows licensed retailers other than the franchise holder to sell power to contestable consumers. Captured consumers become the dwindling residual of the franchise market. Size of consumption, not geography, now defines the retail market of the DUs.

The emergence of DERs will impact mostly the generation segment of the power industry as more and more renewables replace fossil fuel-driven generation. But solar PVs will also impact DU operations on-grid as well as off-grid. DERs will attenuate the retail business of DUs as more and more consumers produce part or all of their requirements. Likewise, there are special problems associated with growth of solar PV systems. For example, adjusting the grid to be compatible with two-way (import and export) flow of electricity in the case of on-grid net-metered systems, and striking the right exchange rate between the power transactions, form a technical and policy hurdle.

Heightened prudence should guide the deployment of capital in the business-as-usual manner going forward to avoid the financial burdens of stranded assets. Incumbent power industry stakeholder should henceforth adopt a more inclusive portfolio of assets which embraces rather than stubbornly resist the march of technology. The goal to raise reserve power should now seriously consider industrial battery storage and not just switchable and fossil fueled peakers. The mothballing by AboitizPower of its subsidiary's ThermaMobile bunker-fueled power barges should be a lesson never to be ignored.

Part 2

Forecasting Near-Term Electricity Demand in the Meralco Franchise Area

A. Forecasting Model for Aggregate Meralco Sales

1. Introduction

Forecasting Frailties

Forecasting is the soft underbelly of the Economics discipline. The reason is that economic reality has both ergodic and non-ergodic aspects. Ergodic phenomena are the realities that the sciences normally deal with. An ergodic phenomenon is one with a known probability distribution over known set of support states of the world which, if temporarily imperfectly known, may be constructed by accumulation of observations. The lack of knowledge associated with an ergodic reality, also called 'risk', is due mainly to the dearth of data. Thus, knowledge and prediction is rendered more and more precise in the ergodic universe with more and more data observations.

Non-ergodic reality is one that may refuse to follow blindly past experience. Either the probability distribution of an ergodic reality is unknown or the states of the world is over, which a probability distribution is defined are not knowable at present since they are 'emergent', that is, in the process of creation. The lack of knowledge associated with a non-ergodic reality is also known as 'uncertainty' (Keynesian or Knightian). Evolutionary Biology is one field where non-ergodicity is prominent which renders predictions of the future tenuous at best.

Forecasting is effectively using the past as a mirror to the future. Winston Churchill once said, "The father back we look, the farther forward we can see." True if reality were only ergodic. But the remote past can also exercise less and less influence on the future. Indeed, to make proper forecast, we may need suppress the weight of the remote past in favor of the more recent past to take on the contribution of more recent non-ergodic influences. This is especially true in that segment of economic reality where innovation is rapid, such as telecommunications, but also in the power industry in the first two decades of the 21st century.

Despite the frailties of forecasting, it remains the backbone of longer term plans and investment projects of firms. It remains the basis upon which contracts are signed and policies are formulated. If we must do it, we do it with great care.

The objective of this section is to develop a forecasting model for aggregate sales of a distribution utility for the period 2018 to 2030. We take as example the aggregate sales of the Meralco franchise since this is the largest among the utilities. The forecasts produced by the model, or some adjusted version of the forecasts, can be used to inform not only the rate-setting exercise between Meralco and the Energy Regulatory Commission but rate setting in general. The methodology can also be useful for other distribution utilities about to embark in similar rate-setting exercise. Specifically, we develop an error correction model (ECM) where Meralco aggregate sales is related to broad economic and demographic variables that are viewed as likely to drive future Meralco sales. Of course, using this model to generate the forecasts also requires forecasting the economic and demographic variables that drive them. For this, we use historical patterns and some judgment. The details of the model and a discussion of the relevant issues are presented below.

2. Meralco Sales

The Meralco franchise area covers NCR and portions of CALABARZON and Southern Tagalog. Based on the Philippine Statistics Authority's (PSA) Regional Accounts of the Philippines in 2017, these three regions combine to account for close to 60 of the country's output and 37% of the country's population. In 2017, Meralco sales totaled 41,389 million kWh, representing an average annual growth of 4.7% per year since 1973, and a lower 3.8% per year since 2000 (Figure A1).

In the past two years and for most years since 2004, by customer type, commercial customers accounted for the biggest share of Meralco sales, followed by residential customers, and followed closely by industrial customers (Table A1). The recent growth pattern in Meralco's sales by customer type partly mirrors the country's economic growth pattern. From year 2000, sales of Meralco to commercial customers has been growing by 4.7% per year, on average, whereas industrial sales has been growing by 3.7%, and residential sales by 3% per year. In the same period, real GDP in the country grew by 5.3% per year, on average, services sector real gross valued added (GVA) by 6% per year, industrial sector GVA by 5.3% per year, and real household consumption by 5.1% per year.

Although the Meralco franchise area covers only three regions, of which two are only covered partially, total Meralco sales has been closely related to real gross domestic product (Figure A2). As described earlier, this is in large part because these three regions make up bulk of the Philippine economy, and is the center of industrial and commercial activities. The correlation coefficient between total Meralco sales and real GDP is 0.97.

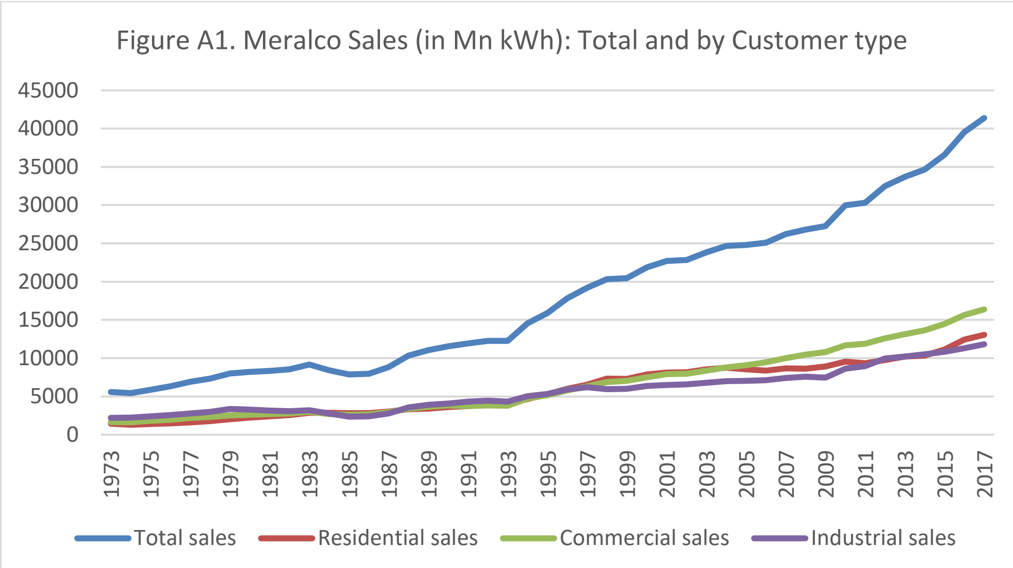
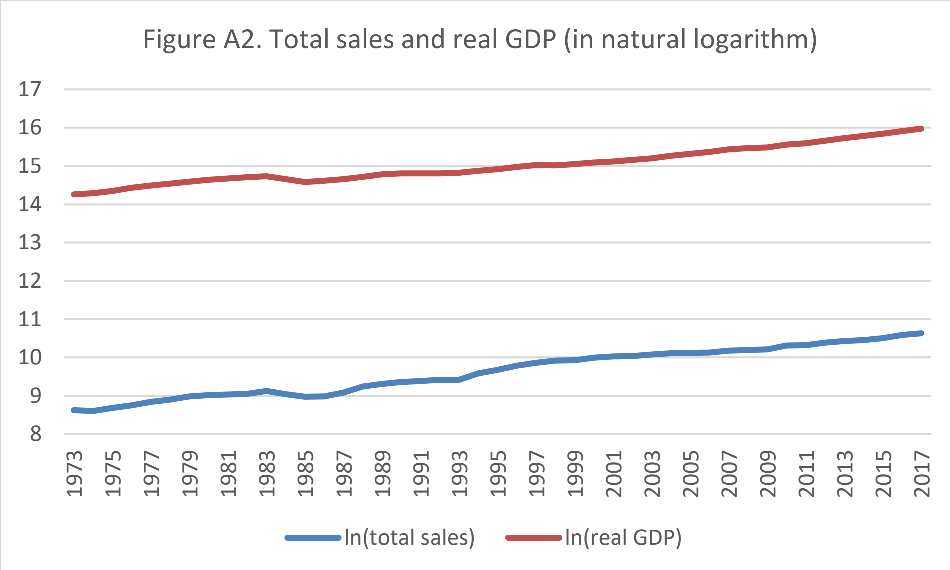


Table A1. Meralco Sales in GWh: Total and by Customer Type, 1973 and 2017

	1973		2017		Annual Growth Rate (%)
	GWh	share	GWh	share	1973-2017
Total sales	5,567	100.0%	41,389	100.0%	4.7
Type of customer					
Residential	1,447	26.0%	13,055	31.5%	5.1
Commercial	1,649	29.6%	16,378	39.6%	5.4
Industrial	2,201	39.5%	11,821	28.6%	3.9



3. Model Framework

Absent any supply constraint, total Meralco sales should follow the demand for electricity, which from economic theory should be a function of income, the price of electricity, and the size of the market (other than income).

We follow the framework used in Danao and Ducanes (2017).[1] Starting from a basic relationship between electricity demand (y) and income (x) and electricity price (p) given as an autoregressive distributed lag (ARDL) model,

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 p_t + \beta_4 p_{t-1} + \beta_5 y_{t-1} + \varepsilon_t \quad (1)$$

where y_t, x_t, and p_t are in natural logarithms and, for stability, $|\beta_5| < 1$. (We follow the convention that lower case italics denote variables in natural logarithms.) In long-run equilibrium, $y_t = y_{t-1}$, $x_t = x_{t-1}$, and $p_t = p_{t-1}$. Hence, (1) simplifies to

$$(1 - \beta_5) y_t = \beta_0 + (\beta_1 + \beta_2) x_t + (\beta_3 + \beta_4) p_t + \varepsilon_t \quad (.2)$$

Thus, the long-run equation is

$$y_t = \frac{\beta_0}{1 - \beta_5} + \frac{\beta_1 + \beta_2}{1 - \beta_5} x_t + \frac{\beta_3 + \beta_4}{1 - \beta_5} p_t + u_t \quad (3)$$

[1] What follows come from Danao and Ducanes (2017).

where $u_t = \frac{\varepsilon_t}{1-\beta_5}$. The short-run dynamics is introduced by subtracting y_{t-1} from both sides of (1) and adding and subtracting $\beta_1 x_{t-1}$ and $\beta_3 p_{t-1}$ on the right-hand side, resulting in the following equation:

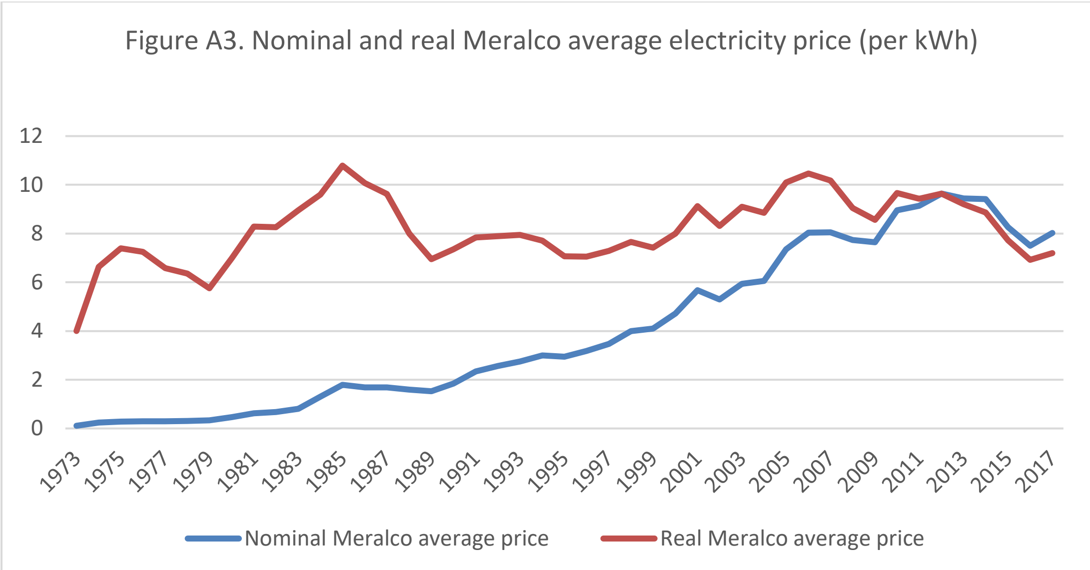
$$\Delta y_t = \beta_1 \Delta x_t + \beta_3 \Delta p_t + (\beta_5 - 1)\left[y_{t-1} - \frac{\beta_0}{1-\beta_5} - \frac{\beta_1 + \beta_2}{1-\beta_5} x_{t-1} - \frac{\beta_3 + \beta_4}{1-\beta_5} p_{t-1}\right] + \varepsilon_t \quad (4)$$

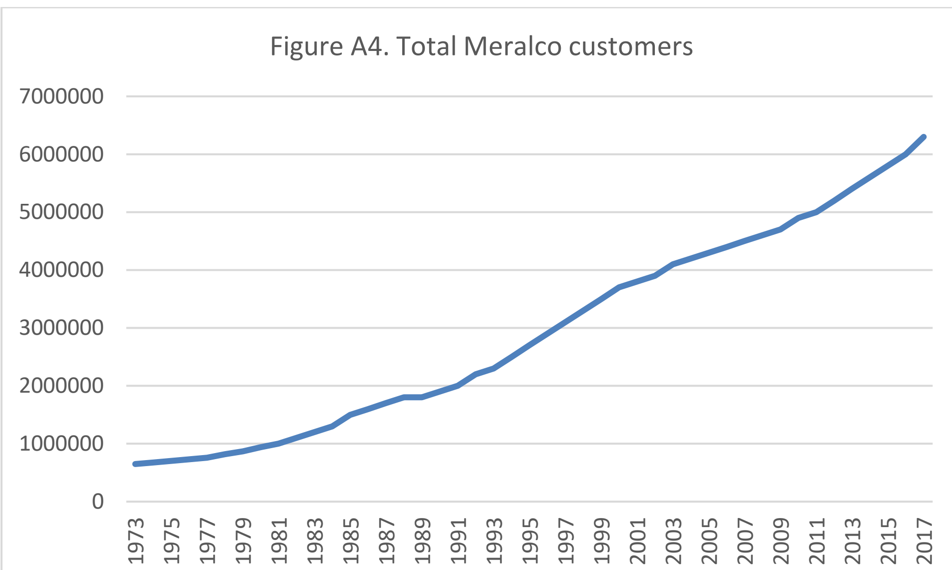
In equation (4), the expression in square brackets is the error term u_{t-1} of the long-run equation (3) and is called the error-correction term. Equation (4) is the Error Correction Model (ECM) formulation of equation (1). Thus, ECM links the short-run dynamics and the long-run equilibrium. The coefficient, $(\beta_5 - 1)$, of the error correction term measures the speed of adjustment to long-run equilibrium after a deviation. Note that the speed of adjustment is negative.

4. Empirical Specification and Data

In the empirical specification of the ECM, we use real GDP as sourced from the PSA as the income variable and employ *ex post* Meralco average price as the nominal price variable. We convert the nominal Meralco average price into a real price by deflating it using the overall consumer price index (Figure A3). We also use the explanatory variable total Meralco customers as a supplementary measure of market size (Figure A4).

The variables used in the model are thus (a) total Meralco sales (Y, in GWh), (b) real GDP (X, in 2000 pesos), (c) real Meralco electricity price (P, in 2012 pesos/kWh), and total Meralco customers (Z, actual count).





Unit Root Tests and Cointegration

Error-correction modeling requires determining the order of integration of each variable and is done by testing for the presence of a unit root. If a series has a unit root and its first difference is stationary or I(0), the series is integrated of order 1 or I(1). Testing for a unit root may be accomplished by using the Augmented Dickey-Fuller (ADF) Test (Dickey and Fuller [1979]). The null hypothesis in an ADF test is that the series under consideration has a unit root. The ADF tests showed that $y_t, x_t,$ and p_t are I(1) and though z_t is I(0) according to the ADF test, an examination of it graphically combined with further ADF test suggests it is actually I(1) (Table A2).

Table A2. Summary of ADF Tests*

Variable	Symbol	Exogenous regressors	t-Statistic (5%)	p-value**	Order of integration
ln(total sales)	y	Constant, linear trend	-2.417	0.1369	I(1)
	Δy	Constant	-4.716	0.0001	I(0)
ln(real GDP)	x	Constant, linear trend	-2.576	0.9991	I(1)
	Δx	Constant	-3.548	0.0068	I(0)
ln(real price)	p	Constant, linear trend	-1.961	0.3039	I(1)
	Δp	Constant	-4.617	0.0001	I(0)
ln(total customers)***	z	Constant	-3.621	0.0054	I(0)
	Δz	Constant	-3.146	0.0233	I(0)

*ADF Tests for all the variables uses data for the period 1987 to 2017; **MacKinnon one-sided p-value; ***ln(total customers) is evidently non-stationary based on the graph of the series (see Figure 4), so we treat it as non-stationary, the first difference looks more stationary and also passes the ADF test

The next step is to determine if the variables of interest are cointegrated, i.e., if in the long-run (static) equation (cointegrating equation)

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 p_t + \beta_3 z_t + \varepsilon_t \tag{5}$$

the error term ε_t is stationary. We employ the Engle-Granger test. The estimation result is in Table A3, showing the estimated coefficients have signs that are expected from theory. The result of the cointegration test is in Table A4, which indicates that the variables of interest are cointegrated.

Table A3. Estimation output of equation (4.1)

Dependent variable: y

	Coefficient	Std. Error	t-Statistic	p-value
x	0.214	0.073	2.94	0.008
p	-0.138	0.045	-3.05	0.007
z	0.808	0.103	7.83	0.000
constant	-5.172	0.482	3.696	0.000

$R^2 = 0.99$

Table A4. Summary of Engle-Granger test for cointegration

Variables	Symbols	t-Statistic	critical value (5%)	Cointegrated?
ln(total sales), ln(real gdp), ln(real price), ln(total customers)	y, x, p, z	-5.305	-4.483	Yes

*Engle-Granger uses data for the period 1987 to 2017;

5. Estimation of the ECM and Statistical Tests

With the long-run relationship in equation (5), we specify an Error Correction Model that captures the short-run dynamics involving not only the short-run effects of real GDP but also of total customer count. After experimenting with different lag structures, we came up with the following single-equation ECM:

ECM1:

$$\Delta y_t = \alpha_1 \Delta x_t + \alpha_2 \Delta z_t + \lambda(y_{t-1} - \beta_0 - \beta_1 x_{t-1} - \beta_2 p_t - \beta_3 z_{t-1}) + v_t \qquad (6a)$$

Or

$$\Delta y_t = \alpha_1 \Delta x_t + \alpha_2 \Delta z_t + \lambda(ect_{t-1}) + v_t \qquad (6b)$$

where ect_{t-1} is the error correction term corresponding to the terms inside the parenthesis in 6a.

We estimated (6b) using the two-step residual-based Engle-Granger method for the period 1995 to 2017. The results are shown in Table A5.

Table A5. Estimated ECM1: Total Annual Meralco Sales

Dependent variable: Δy

	Coefficient	Std. Error	t-Statistic	p-value
Constant	-0.038	0.010	-2.96	0.008
Δx	0.679	0.184	3.94	0.001
Δz	1.227	0.144	6.67	0.000
ect_{-1}	-0.667	0.130	-4.63	0.000
$F = 27.14$				0.0000
$R^2 = 0.81$				

The estimated equation passes the usual diagnostic tests, namely the Ramsey's RESET test for specification error, the Breusch Godfrey Serial Correlation LM Test, the Breusch-Pagan-Godfrey Heteroskedasticity Test, and the Jarque-Bera Test for Normality of Residuals. A summary of the test results is in Table A6.

Table A6. Summary of Statistical Diagnostic Tests for ECM

Test	H_0	Statistic	p-value
Ramsey's RESET	No specification error	0.56	0.646
Breusch-Godfrey Serial Correlation LM Test	No serial correlation	0.363	0.546
Breusch-Pagan-Godfrey Heteroskedasticity Test	No heteroskedasticity	0.02	0.880
Jarque-Bera Normality Test	Normal residuals	0.45	0.799

The estimated equation in ECM equation form is given by:

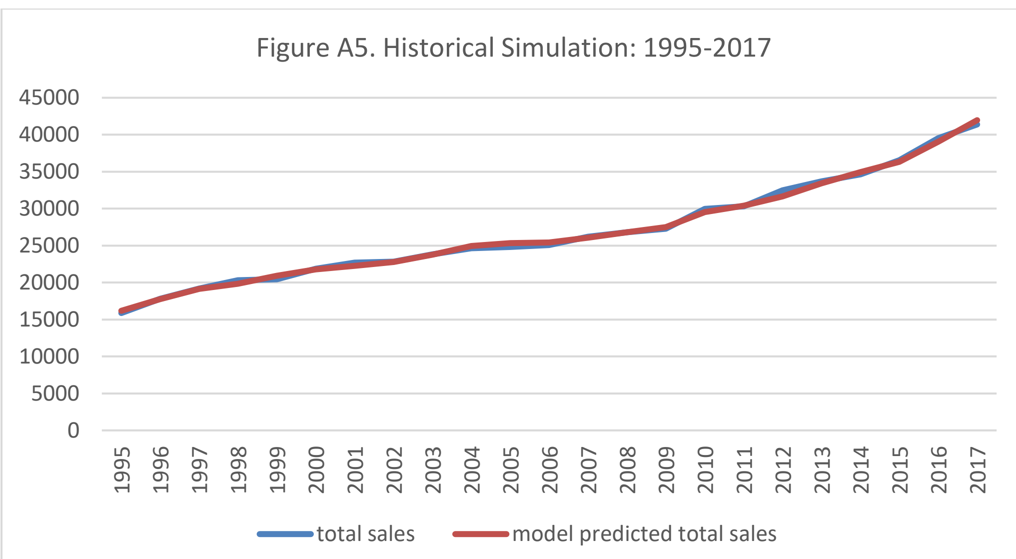
$$\Delta y_t = -0.04 + 0.68\Delta x_t + 1.23\Delta z_t - 0.67(y_{t-1} + 5.17 - 0.21x_{t-1} + 0.14p_t - 0.81z_{t-1}) + v_t$$

The results show that in both the short run and the long run real GDP and customer count have significant positive effects on electricity consumption while price has significant long-run effects. The speed of adjustment is estimated at -0.67, which is consistent with convergence toward a long-run equilibrium, and is significantly different from zero.

The estimated short-run income elasticity of Meralco sales is 0.68 and the long run elasticity is 0.21 (after controlling for the other variables in the model). The estimated short-run customer count elasticity of Meralco sales to real GDP is 1.23 and the long run elasticity is 0.81. The estimated long-run price elasticity of Meralco sales is estimated at -0.14.

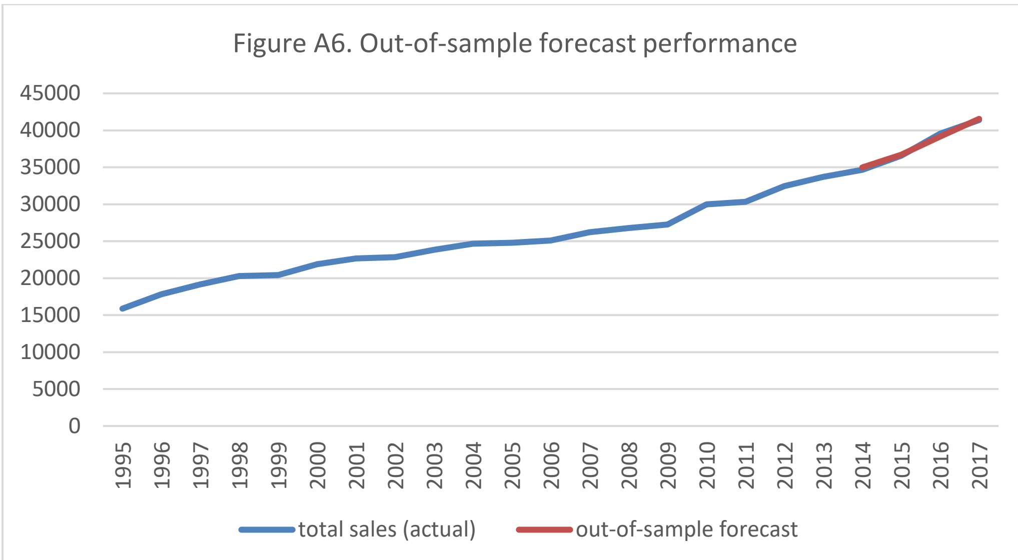
6. Model Forecasting Performance

The estimated model performs well in historical simulation with a Mean Absolute Percent Error (MAPE) of 1.07% and a Mean Percent Error (MPE) of 0.01%, the former implying that the historical forecasts are, on average, only one percent off the actual values and the latter implying that the forecast errors are essentially centered around zero. The actual and forecasted Meralco market sales are graphically shown in Figure A5.



Out-of-Sample Forecast performance

We also tested the model using out-of-sample forecasts, or forecasts for which actual values are known but are outside the estimation period. We re-estimated the model over the sample period 1995-2013, which makes 2014-2017 the holdout period. For the values of the predictor variables, we use the actual values, so that it is only the estimated parameters that are essentially being evaluated. The MAPE for the out-of-sample forecast is 0.66% and the MPE is -0.20%, both of which are reasonably low. This is graphically shown in Figure A6.



7. Forecasting

This section presents the results of simulations for the forecast horizon 2018-2030. We stipulate a baseline forecast where the drivers of Meralco sales (real GDP, average real Meralco electricity price, and customer count) follow historical trends. Several alternative scenarios examine how changes in these drivers affect Meralco sales in the next 13 years when compared with the baseline forecast.

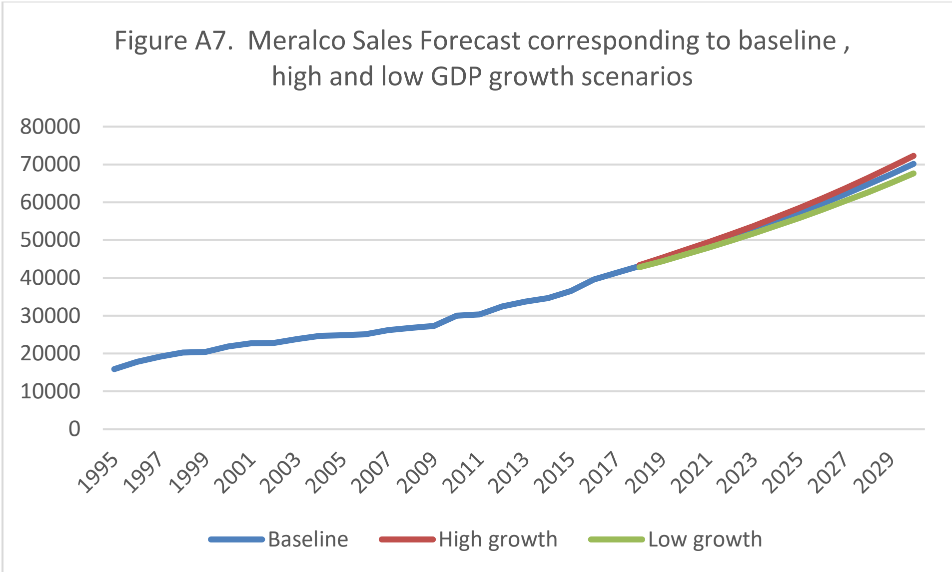
The baseline forecast assumes the following: real GDP grows at a rate of 6.1% per year, or at about the ‘potential’ or sustainable growth rate of the Philippines according to BSP and ADB; average real Meralco electricity price at the 2017 level, and customer count growing at 3.5% per year or at about its average growth the previoust 10 years). The results are given as Scenario 1 (Baseline) in Table A7 The detailed forecasts are in Annex Table A1. Under the baseline forecast, Meralco sales will grow at an average annual rate of 4.1% from 41,289 GWh in 2017 to 70,138 GWh by 2030, an increase of 69%.

Table A7. Simulated Effects of Alternative Scenarios

Scenario Number	Assumptions	Forecast Annual Growth Rate: 2018-2030	Forecast for 2030 (GWh)	% Increase over base case
1. Baseline GDP Growth	GDP annual growth rate: 6.1% Real price: 2017 level Customer count: 3.5%	4.14%	70,138	
2. High GDP Growth	GDP annual growth rate: 7% Real price: 2017 level Customer count: 3.5%	4.38%	72,250	3
3. Low GDP Growth	GDP annual growth rate: 5% Real price: 2017 level Customer count: 3.5%	3.85%	67,616	- 3.6
4. Price Reduction	GDP annual growth rate: 6.1% Real price: decline of 0.5% per year from 2017 level Customer count: 3.5%	4.20%	70,684	0.8
5. Price Increase	GDP annual growth rate: 6.1% Real price: increase of 0.5% per year from 2017 level Customer count: 3.5%	3.45%	69.598	-0.8
6. High customer count Increase	GDP annual growth rate: 6.1% Real price: 2017 level Customer count: 5%	5.35%	82,349	17.4
7. Low customer count Increase	GDP annual growth rate: 6.1% Real price: 2017 level Customer count: growth of 2%	2.90%	59,596	-15. 0

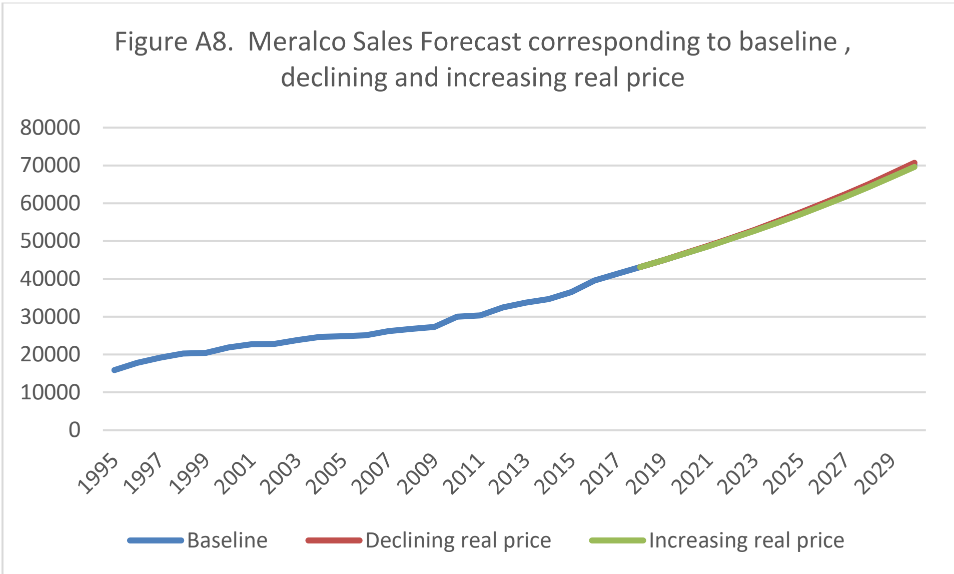
The Impact of High and Low GDP Growth Rates

The high GDP growth rate (Scenario 2) assumes a growth rate of 7% per year while the low GDP growth rate (Scenario 3) assumes 5% per year. Price is assumed fix at the 2017 level and customer count is assumed to be growing at 3.5% per year. Under the high GDP growth scenario, Meralco sales will grow at the rate of 4.38% per year and by 2030, electricity consumption will reach 72,250 GWh, about 3% higher than under the baseline scenario. Under the low GDP growth scenario, electricity consumption will grow at 3.85% per year and by 2030, electricity consumption will reach 67,616 GWh which is 3.6% lower than under the baseline scenario. The three scenarios are graphed in Figure A7.



The Impact of Price Changes

In Scenario 4 we assume the baseline scenario for GDP growth (6.1%), a 0.5% per year decline in real electricity price, and a customer count that grows at 3.5% per year. The effect is to increase the growth rate of Meralco sales slightly from 4.14% to 4.2% per year and by 2030, electricity consumption will reach 70,684 GWh, just about 0.8% higher than under the baseline scenario. In Scenario 5 we instead assume a 0.5% per year increase in real electricity price but keep the other assumptions the same. The effect is to reduce the growth rate of Meralco sales slightly from 4.14% to 4.08% per year and by 2030, electricity consumption will reach 69,598 GWh, just about 0.8% lower than under the baseline scenario. The scenarios including the baseline are graphed in Figure A8.



The Impact of Changes in Growth of Customer Count

In Scenario 6 we assume the baseline scenario for GDP growth, real electricity price at its 2017 level, and a customer count that grows at 5% per year. The effect is to increase the growth rate of Meralco sales 4.14% to 5.37% per year and by 2030, electricity consumption will reach 81,716 GWh, about 16.5% higher than under the baseline scenario. Finally, in Scenario 7, we instead assume a customer count that grows at 2% per year but keep the other assumptions the same. The effect is to reduce the growth rate of Meralco sales from 4.14% to 2.78% per year and by 2030, electricity consumption will reach 59,132 GWh, or about 15.7% lower than under the baseline scenario. The scenarios including the baseline are graphed in Figure A9.

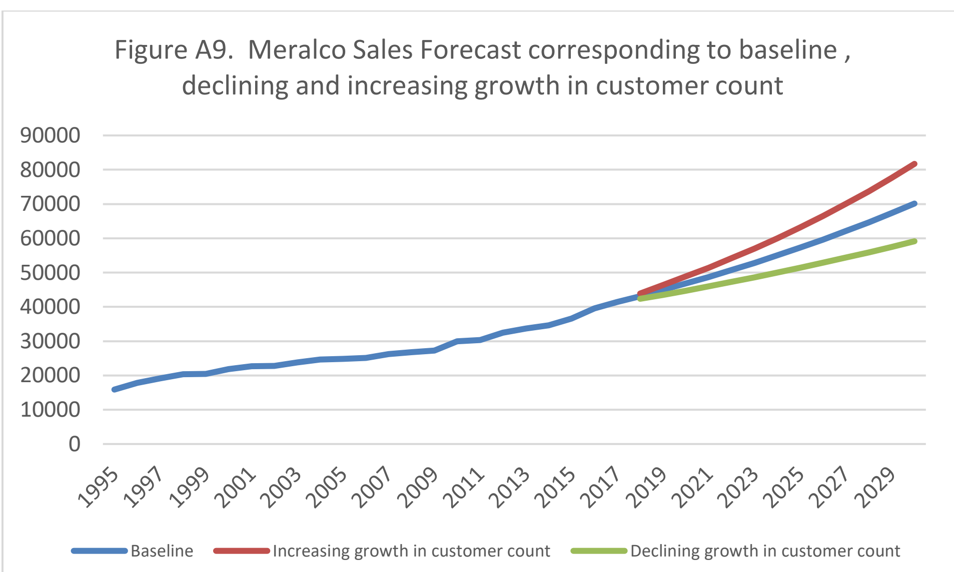


Table. Forecast of Total Meralco Sales

Year	1. Baseline GDP Growth	2. High GDP Growth	3. Low GDP Growth	4. Price Reduction	5. Price Increase	6. High customer Count	7. Low customer Count
1995	15,876	15,876	15,876	15,876	15,876	15,876	15,876
1996	17,810	17,810	17,810	17,810	17,810	17,810	17,810
1997	19,180	19,180	19,180	19,180	19,180	19,180	19,180
1998	20,306	20,306	20,306	20,306	20,306	20,306	20,306
1999	20,433	20,433	20,433	20,433	20,433	20,433	20,433
2000	21,881	21,881	21,881	21,881	21,881	21,881	21,881
2001	22,689	22,689	22,689	22,689	22,689	22,689	22,689
2002	22,822	22,822	22,822	22,822	22,822	22,822	22,822
2003	23,834	23,834	23,834	23,834	23,834	23,834	23,834
2004	24,660	24,660	24,660	24,660	24,660	24,660	24,660
2005	24,806	24,806	24,806	24,806	24,806	24,806	24,806
2006	25,078	25,078	25,078	25,078	25,078	25,078	25,078
2007	26,219	26,219	26,219	26,219	26,219	26,219	26,219
2008	26,799	26,799	26,799	26,799	26,799	26,799	26,799
2009	27,275	27,275	27,275	27,275	27,275	27,275	27,275
2010	29,976	29,976	29,976	29,976	29,976	29,976	29,976
2011	30,314	30,314	30,314	30,314	30,314	30,314	30,314
2012	32,471	32,471	32,471	32,471	32,471	32,471	32,471
2013	33,704	33,704	33,704	33,704	33,704	33,704	33,704
2014	34,649	34,649	34,649	34,649	34,649	34,649	34,649
2015	36,563	36,563	36,563	36,563	36,563	36,563	36,563
2016	39,532	39,532	39,532	39,532	39,532	39,532	39,532
2017	41,389	41,389	41,389	41,389	41,389	41,389	41,389
2018	43,126	43,374	42,821	43,126	43,126	43,894	42,360
2019	44,916	45,316	44,428	44,937	44,896	46,344	43,513
2020	46,774	47,296	46,138	46,825	46,724	48,858	44,751
2021	48,707	49,347	47,929	48,792	48,622	51,483	46,043
2022	50,719	51,480	49,795	50,842	50,596	54,241	47,379
2023	52,813	53,704	51,735	52,979	52,649	57,143	48,756
2024	54,994	56,023	53,751	55,205	54,786	60,199	50,174
2025	57,265	58,443	55,846	57,524	57,009	63,418	51,633
2026	59,630	60,966	58,022	59,941	59,322	66,809	53,134
2027	62,093	63,598	60,284	62,460	61,729	70,382	54,679
2028	64,657	66,344	62,633	65,084	64,234	74,145	56,270
2029	67,327	69,209	65,075	67,819	66,840	78,110	57,906
2030	70,107	72,197	67,611	70,669	69,553	82,287	59,590

Ave. annual growth 2018 to 2022	4.15%	4.46%	3.77%	4.20%	4.10%	5.56%	2.74%
Ave. annual growth 2018 to 2030	4.13%	4.32%	3.90%	4.20%	4.06%	5.35%	2.91%

B. Forecasting Meralco Sales by Customer-Type

1. Introduction

The objective of this section is to develop forecasting models for Meralco sales by customer-type, to supplement the aggregate sales model in the previous section. Meralco customers are classified into three categories: commercial customers; residential customers; and industrial customers. The sales to the three customer-types when added to Meralco's own electricity use and system loss add up to total Meralco sales.

The main reason for modeling electricity demand by customer-type rather than just in the aggregate is that the factors that might impact sales could differ by customer-type and, in addition, the elasticity of electricity sales with respect to the corresponding income, price and other explanatory variables are likely to also differ by customer-type. For instance, whereas, as was shown in the previous section, aggregate Meralco electricity sales is closely linked to real GDP, it might be the case that sales to a specific customer-type might be more strongly linked to a subsector of the economy. In fact, the models that we will present later use real services sector gross value added (GVA) as the income variable for commercial customers' sales, real industrial GVA as the income variable for industrial customers' sales, and real household consumption expenditure for residential customers' sales.

2. Methodology and Data

We modeled Meralco electricity sales by customer-type using either an error correction model (ECM) or an autoregressive distributed lag (ARDL) model, depending on the presence of cointegration. The ECM was already discussed in the section on the aggregate electricity sales forecast. The ARDL model can be thought of as the ECM without the error correction term, meaning what is modeled is the change in the dependent variable as a function of changes in the explanatory variable/s and its lags as well as possibly the lags of the change in the dependent variable. In the end, we used ECMs for the models on commercial customers and residential customers and an ARDL model for the model on industrial customers.

For each customer-type, we attempted to model electricity sales as a function of income, price, and number of customers. We allowed for the possibility that the appropriate income variable may differ for the different sectors. We employed customer type-specific prices and number of customers.

Sales by customer-type was obtained from Meralco. In the model for commercial customers, income was proxied by real GVA in the services sector, which was obtained from the Philippine Statistical Authority (PSA). The price used for this model was the average price charged by MERALCO to commercial customers deflated to year 2012 level using the overall CPI (from the PSA). The other explanatory variable is the number of commercial customers also from Meralco. In the model for household customers, the income variable used was the real household consumption expenditure (from the PSA). The price variable used was the average price charged by MERALCO to residential customers after deflating to year 2012 level using the CPI. And the only other variable used was the number of residential customers obtained from Meralco. For industrial customers, the income variable used was the industrial sector real GVA (from the PSA), and it was the only explanatory variable that came into play in the model. The summary statistics of the variables that go into the models by customer-type for the period 1995 to 2017 are presented in Table B1. The test results for the order of integration of the regression variables (in natural logarithm) are in Annex Table B1, which show that, except for number or residential customers, all the variables are integrated of order one.[2]

Table B1. Summary Statistics of Regression Variables (for period 1995 to 2017)

Variable	Obs	Mean	Std. Dev.	Min	Max
$Q_{comsales}$	23	10043	3184	5140	16378
$Q_{ressales}$	23	8818	1845	5294	13055
$Q_{indsales}$	23	7885	1963	5327	11821
$SERVGVA_{real}$	23	2779435	1049256	1488027	4979575
$HHCONS_{real}$	23	3587279	1149536	2071341	5973817
$INDGVA_{real}$	23	1690516	552485	1073061	2947104
$P_{comelec}$	23	9	1	7	11
$P_{reselec}$	23	9	1	7	11

[2] According to the Dickey-Fuller tests, the undifferenced number of residential customers (in natural logarithm) is already stationary at the 5% level. But plotting this variable over time in both level and first difference suggests it is integrated of order 1. We use our judgment and treat it as integrated of order 1, or to only become stationary after first differencing.

$N_{comelec}$	23	381561	77888	237576	498404
$N_{reselec}$	23	4025438	932651	2406959	5811307

*The variables are defined in the next section

3. Estimated Sectoral Models

3.1. Commercial Sales

Using data from 1995 to 2017, we found Meralco commercial sales to be cointegrated with services real GVA, real average Meralco commercial electricity price, and the number of commercial customers.[3] Equation 1 shows our chosen error correction model for commercial sales. [The regression result pertaining to Equation 1 is in Annex Table B3 and the results of the diagnostic tests are in Annex Table B4.] We estimated the long run elasticity of commercial sales with respect to services real GVA at 0.40 (controlling for the number of commercial customers and commercial electricity price), meaning a one percent increase in real services GVA leads to an increase in commercials sales of about four-tenths of one percent in the long run, again controlling for the number of customers and price. The long run elasticity of commercial sales with respect to number of commercial customers is estimated at 0.82, and with its elasticity with respect to commercial electricity price is estimated at -0.15, (controlling for the other variables in the regression). The estimated model shows a short-run elasticity of commercials sales with respect to real services GVA of 0.47 percent – meaning a one percent increase in real services GVA leads to a 0.47 percent increase in commercials sales in the short run. The short-run elasticity of commercials sales with respect to the number of commercial customers is 0.74. There was no meaningful relationship obtained between commercial sales and commercial electricity prices in the short run. The speed of adjustment to the long-run equilibrium of the ECM is estimated at 0.52.[4]

Equation 1. Residential Sector Model

$$
\begin{aligned}
\Delta \ln\left(q_{comsales_t}\right)
&= 0.47\Delta \ln\left(servgva_{real_t}\right) + 0.74\Delta \ln\left(n_{comelec_t}\right) + 0.001 \\
&- 0.52\,(\ln\left(q_{comsales_{t-1}}\right) - 7.00 - 0.40 \ln\left(servgva_{real_{t-1}}\right) - 0.82 \ln\left(n_{comelec_{t-1}}\right) \\
&+ 0.15 \ln\left(p_{comelec_{t-1}}\right))
\end{aligned}
$$

[3] See Annex Table B2 for Engle-Granger test results.

[4] The model has an R-squared of 60 percent, and passes tests for serial correlation heteroscedasticity, mis-specification, and normality of residuals.

where $q_{comsales}$ = Meralco commercial sales in GWh

$servgva_{real}$ = real services GVA

$n_{comelec}$ = number of commercial customers

$p_{comelec}$ = Meralco average price to commercial customers deflated to 2012 prices using CPI

3.2. Residential Sales

Using data from 1995 to 2017, we found Meralco residential sales to be cointegrated with real average Meralco residential electricity price, and the number of residential customers.[5] Equation 2 shows our chosen error correction model for residential sales. [The regression result pertaining to Equation 2 is in Annex Table B5 and the results of the diagnostic tests are in Annex Table B4.] We estimated the long run elasticity of residential sales with respect to number of residential customers at 0.94, and its elasticity with respect to residential electricity price is estimated at -0.20. The estimated model shows a short-run elasticity of residential sales with respect to the number of residential customers of 1.24, and an elasticity with respect to real household consumption of 0.81. There was no meaningful relationship obtained between residential sales and residential electricity price in the short run. The speed of adjustment to the long-run equilibrium of the ECM is estimated at 0.64.[6]

Equation 2. Residential Sales Model

$$\Delta \ln\left(q_{ressales_t}\right) = 0.81\Delta \ln\left(hhcons\ _t\right) + 1.24\Delta \ln\left(n_{reselec_t}\right) - 0.049 - 0.64(\ln\left(q_{ressales_{t-1}}\right) - 0.94 \ln\left(n_{comelec_{t-1}}\right) + 0.20 \ln\left(p_{comelec_{t-1}}\right) + 4.77)$$

where $q_{comsales}$ = Meralco residential sales in GWh

$hhcons_{real}$ = real household consumption expenditure

$n_{reselec}$ = number of residential customers

$p_{reselec}$ = Meralco average price to residential customers deflated to 2012 prices using CPI

[5] See Annex Table B2 for Engle-Granger test results.

[6] The model has an R-squared of 83 percent, and passes tests for serial correlation heteroscedasticity, mis-specification, and normality of residuals.

3.3. Industrial Sales

Because we were not able to find a cointegrating equation for industrial sales, we model it using an ARDL model instead of an ECM. Using data from 1995 to 2017, we model changes in (the natural logarithm) industrial sales as a function of change (in the natural logarithm) real industrial GVA plus two time dummy variables, to take into account apparent changes in the relationship between industrial sales growth and real industrial GVA growth.[7] The time dummies were for the period 2010 to 2012, a period when industrial sales growth was consistently much higher than real industrial GVA growth, and for the period 2013 onwards when industrial sales growth was consistently much lower than real industrial GVA growth. The short-run elasticity of industrial sales with respect to real industrial GVA is estimated at 1. Equation 3 shows our chosen ARDL model for industrial sales. [The regression result pertaining to Equation 3 is in Annex Table B6 and the results of the diagnostic tests are in Annex Table B4.][8]

Equation 3. Commercial Sector Model

$$\Delta\ln\left(q_{indsales_t}\right) = 1.00\Delta\ln\left(indgva_{real_t}\right) + 0.036\Delta \mathrm{y2010t2012} - 0.03\mathrm{y2013t} - 0.003)$$

where	$q_{indsales}$	= Meralco industrial sales in GWh
	$indgva_{real}$	= real industrial GVA
	$y2010t2012$	= dummy: 1 if year is from 2010 to 2012; 0 otherwise
	$y2013t$	= dummy: 1 if year is from 2010 to 2012; 0 otherwise

4. Measures of Forecasting Performance

4.1. Within-sample goodness-of-fit

Figure B1 illustrates the within-sample prediction performance of the models for each customer-type and shows good historical fit of each of the models. This can also be seen in Table B2, which shows three standard measures of prediction accuracy for each model, which are the mean squared error (MSE), the mean percent error (MPE), and the mean absolute percent error (MAPE). The MPEs for all sectors are close to zero, especially for the residential and commercial sectors which indicate that the models' predictions are close to unbiased historically. The MAPEs, which show how far on average the

[7] The time dummies were suggested by an analysis of the residuals.

[8] The model has an R-squared of 76 percent, and passes tests for serial correlation heteroscedasticity, and normality of residuals.

predictions are from the actual values as a percentage of the actual values, are also relatively low, ranging from 1.33 to 1.73.

Figure B1. Within-sample Goodness-of-Fit

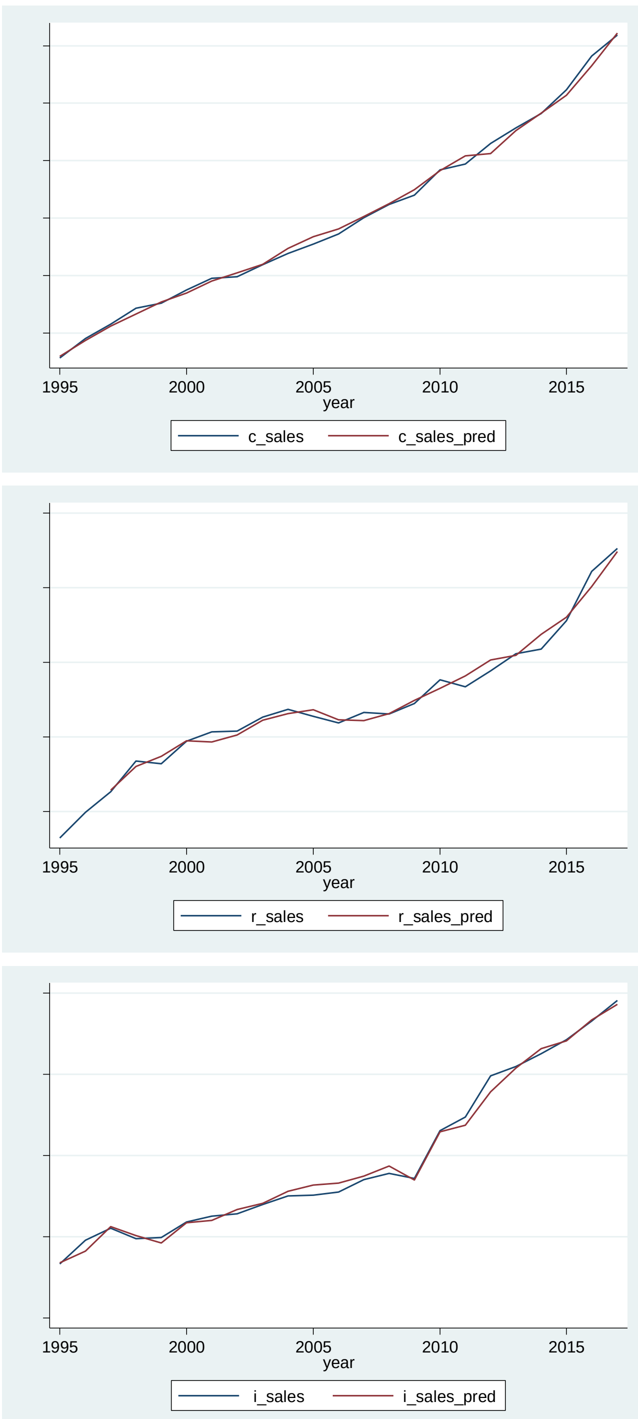


Table B2. Within-sample forecasting accuracy

Sectoral Model	MSE	MPE	MAPE
Commercial	27,239	-0.013	1.33
Residential	38,557	-0.021	1.73
Industrial	22,062	-0.019	1.51

4.2. Out-of-sample forecasting accuracy

To measure out-of-sample forecasting accuracy for the chosen models, we re-estimated each for observations only up to 2013. We then used the estimated models to forecast Meralco sales by customer-type from 2014 to 2017. For this exercise, the values used for the (assumed) exogenous variables from 2014 to 2017 were their actual values for the period.[9]

Figure B2 illustrates the out-of-sample forecasting performance of the models by customer-type. Table B3 shows the out-of-sample accuracy measures. For the commercial sales model, the MPE is the same as the MAPE, which indicates that all the percent errors were of the same sign (positive). However, a closer look at the data shows the percent error was very close to zero in both 2014 and 2017, and was no greater than 2.6 in between, and in fact the out-of-sample MAPE for the commercial sector is lower than the within-sample MAPE. For residential sales, the MPE was close to zero but the MAPE was higher compared to the within-sample period at 2.11 compared to 1.73. For industrial sales, the MPE is close to zero and the MAPE is less than one percent, indicating good out-of-sample fit.

[9] Essentially, the exercise tries to answer this question for each sectoral model: If the scenarios envisioned for the exogenous variables are realized, will the model generate accurate forecasts of electricity demand for the sector?

Figure B2. Out-of-sample Goodness-of-Fit

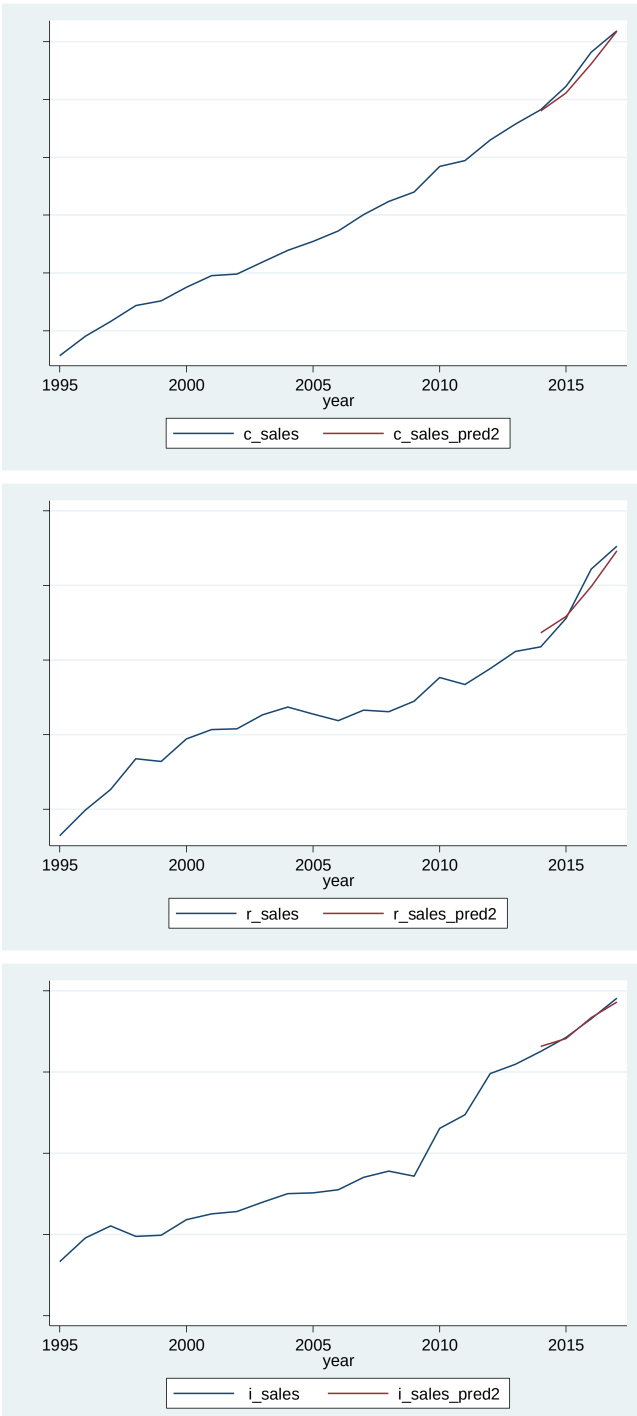


Table B3. Out-of-sample forecasting accuracy

Sectoral Model	MSE	MPE	MAPE
Commercial	57,645	1.14	1.14
Residential	81,961	-0.169	2.11
Industrial	6,068	-0.102	0.602

5. Model Forecasts

In this section, we use the models by customer-type to forecast Meralco electricity sales by customer-type from 2018 to 2030. The forecasts assume that real GDP will grow by 6.1 percent per year from 2018 to 2030, and that real services GVA and real industrial GVA will both grow by 6.6 percent per year, and that real household consumption expenditure will grow at 6.1 percent per year, or at the same rate as GDP.[10] The forecasts likewise assume that real Meralco prices by customer-type will be at their 2017 level for the forecast period. Finally, the forecasts also assume that the number of customers by customer type will be growing at their average rate either in the past 10 years (2.2 percent per year for commercial customers and 3.8% per year for residential customers) or the past 5 years (1 percent per year for industrial customers, since average growth for industrial customers in past 10 year is negative).

The forecasts are in Table B4. It shows that commercial sales is forecasted to grow at around 4.5 percent per year, residential sales at about 3.8 percent per year, and industrial sales at 3.1 percent per year. The sum of the sales to the three customer-types is forecasted to growth at about 3.9% per year to 2030.

[10] The 6.6 percent annual growth for both services and industry assumes that agriculture will grow at 3 percent per year.

Table B4. Forecast of Meralco Sales by Customer-type

Year	Commercial	Growth in % per year	Residential	Growth in % per year	Industrial	Growth in % per year	Sum of Commercial, Residential, and Industrial	Growth in % per year
1995	5,140		5,294		5,327		15,761	
1996	5,805		5,976		5,909		17,690	
1997	6,314		6,526		6,213		19,053	
1998	6,870		7,348		5,953		20,171	
1999	7,038		7,284		5,974		20,297	
2000	7,507		7,880		6,360		21,748	
2001	7,906		8,138		6,503		22,547	
2002	7,962		8,152		6,562		22,676	
2003	8,376		8,527		6,791		23,694	
2004	8,777		8,742		7,004		24,522	
2005	9,095		8,551		7,019		24,664	
2006	9,455		8,377		7,104		24,935	
2007	10,021		8,655		7,405		26,081	
2008	10,481		8,616		7,563		26,660	
2009	10,796		8,900		7,439		27,134	
2010	11,683		9,535		8,616		29,834	
2011	11,886		9,340		8,947		30,174	
2012	12,602		9,775		9,964		32,341	
2013	13,148		10,231		10,197		33,576	
2014	13,646		10,360		10,513		34,519	
2015	14,464		11,117		10,850		36,432	
2016	15,648		12,439		11,311		39,398	
2017	16,378		13,055		11,821		41,254	
2018	17,107	4.5%	13,505	3.5%	12,192	3.1%	42,804	3.8%
2019	17,869	4.5%	13,999	3.7%	12,575	3.1%	44,443	3.8%
2020	18,666	4.5%	14,520	3.7%	12,970	3.1%	46,156	3.9%
2021	19,499	4.5%	15,064	3.7%	13,377	3.1%	47,940	3.9%
2022	20,370	4.5%	15,629	3.8%	13,798	3.1%	49,796	3.9%
2023	21,279	4.5%	16,217	3.8%	14,231	3.1%	51,726	3.9%
2024	22,228	4.5%	16,826	3.8%	14,678	3.1%	53,732	3.9%
2025	23,220	4.5%	17,459	3.8%	15,139	3.1%	55,818	3.9%
2026	24,257	4.5%	18,115	3.8%	15,614	3.1%	57,986	3.9%
2027	25,339	4.5%	18,796	3.8%	16,104	3.1%	60,240	3.9%
2028	26,470	4.5%	19,503	3.8%	16,610	3.1%	62,583	3.9%
2029	27,652	4.5%	20,236	3.8%	17,132	3.1%	65,020	3.9%
2030	28,886	4.5%	20,997	3.8%	17,670	3.1%	67,552	3.9%

C. Summary of Part 2

Part 2 was intended to forecast the electricity demand for a distribution utility in the near term taking as an example the Meralco franchise electricity market. The reason for the choice is simple: the correlation coefficient between Meralco sales and PHL GDP is 0.97. Our error correction forecasting model is passes all the state-of-the-art tests for robustness including co-integration and within-sample and out-of-sample predictive power. We also carry various simulation runs. The model employed can be used by other distribution utilities to forecast their own short term demand. The results can then be used to inform the rate-setting exercise betweem Meralco and the regulator, ERC. The model use data from 1995 to capture more recent disruptors to and trends such as more efficient appliances, smaller dwelling choices, smaller families in the power industry.

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Annex Table B1. Augmented Dickey-Fuller Test for Unit Root

Variable (in natural logarithm)	Level test statistic	p-value	First-difference test statistic	p-value
q_{comsales}	-1. 67	0.449	-5.04	0.000
q_{ressales}	-1.88	0.340	-4.10	0.001
q_{indsales}	-2.64	0.086	-4.36	0.000
$servgva_{\text{real}}$	2. 93	0.999	-2.90	0.046
$hhcons_{\text{real}}$	0.34	0.996	-4.44	0.002
$indgva_{\text{real}}$	1.88	0.999	-4.43	0.000
p_{comelec}	-2.62	0.089	-4.25	0.001
p_{reselec}	-2.42	0.135	-5.05	0.000
n_{comelec}	-0.19	0.992	-5.00	0.000
n_{reselec}	-3.22	0.019	-3.26	0.017

Note: ADF tests tor the $hhcons_{real}$ and $n_{comelec}$ variables included a trend term, and for the $q_{indsales}$ included a lag term of order 1.

Annex Table B2. Engle-Granger Tests Results

Customer Type	Variables	Test Statistic	1%	5%	10%
Commercial**	ln($q_{comsales}$), ln($servgva_{real}$), ln($p_{comelec}$), ln($n_{comelec}$)	-4.86	-5.46	-4.58	-4.17
Residential**	ln($q_{commelec}$), ln($servgva_{real}$), dummy (1=pre-1999; 0=1999 and on)	-5.29	-5.289	-4.483	-4.095

**Significant at 5% level; ***Significant at 10% level

Annex Table B3: Chosen Model for Commercial Sales

2nd Stage Dependent variable: Δln(q_comelec)

F-stat =	9.52
p-value =	0.00
R-squared =	0.60
No. of obs. =	23

Explanatory variable	Coefficient	t-stat	p-value
Δln(servgva_real)	0.466	1.65	0.115
Δln(n_comelec)	0.742	3.33	0.004
L.ECT	-0.521	-3.79	0.001
Constant	-0.001	0.07	0.542

1st Stage Dependent variable: ln(q_comelec)

F-stat =	1072.57
p-value =	0.00

R-squared = 0.99

No. of obs. = 23

Explanatory variable	Coefficient	t-stat	p-value
ln(servgva_real)	0.403	4.47	0.000
ln(n_comelec)	0.822	5.10	0.000
ln(p_comelec)	-0.154	-2.03	0.056
Constant	7.005	10.56	0.000

Annex Table B4: Regression Diagnostic Tests Results

Diagnostic test results		**p-value**		
Diagnostic test/MAPE	**Null Hypothesis**	**Commercial Sales Model**	**Residential Sales Model**	**Industrial Sales Model**
Ramsey test	No mis-specification	0.77	0.68	0.00
Breusch-Pagan	Constant Variance	0.67	0.78	0.58
Breusch-Godfrey test	No serial correlation	0.28	0.85	0.12
Jarque-Bera	Normally distributed residuals	0.67	0.22	0.32

Annex Table B5: Chosen Model for Residential Sales

2nd Stage Dependent variable: Δln(q_reselec)

F-stat =	25.42
p-value =	0.00
R-squared =	0.80
No. of obs. =	23

Explanatory variable	Coefficient	t-stat	p-value
Δln(hhcons_real)	0.811	1.89	0.075
Δln(n_reselec)	1.238	4.07	0.001
L.ECT	-0.640	-4.90	0.000
Constant	-0.049	-2.03	0.057

1st Stage Dependent variable: ln(q_reselec)

F-stat =	346.88
p-value =	0.00
R-squared =	0.97
No. of obs. =	23

Explanatory variable	Coefficient	t-stat	p-value
ln(n_comelec)	0.941	23.15	0.000
ln(p_comelec)	-0.204	-3.18	0.005
Constant	-4.768	-8.72	0.000

Annex Table B6: Chosen Model for Industrial Sales

Dependent variable: Δln(q_indelec)

F-stat =	19.72
p-value =	0.00
R-squared =	0.76
No. of obs. =	23

Explanatory variable	Coefficient	t-stat	p-value
Δln(indgva_real)	1.002	6.43	0.000
Δy1010t2012	0.036	2.12	0.047
y2013t	-0.029	-2.21	0.040
Constant	-0.003	-0.42	0.679