New trends in the South East Asia power industry and key implications for Myanmar in the short and long-term

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6th September 2016

THE LANTAU GROUP
strategy & economic consulting

Agenda

- Fundamentals across South East Asia
    - Demand and generation dynamics
    - Future supply outlook
    - ASEAN Power Grid
- Emerging trends and themes in South East Asia
    - Renewables outlook and incentives
    - Wind or solar?
    - A turning point in RE economics
    - Off-grid application
- Implications for Myanmar in the short and long-term
    - Not a one-size-fits-all approach
    - National Electrification Plan
    - Next steps

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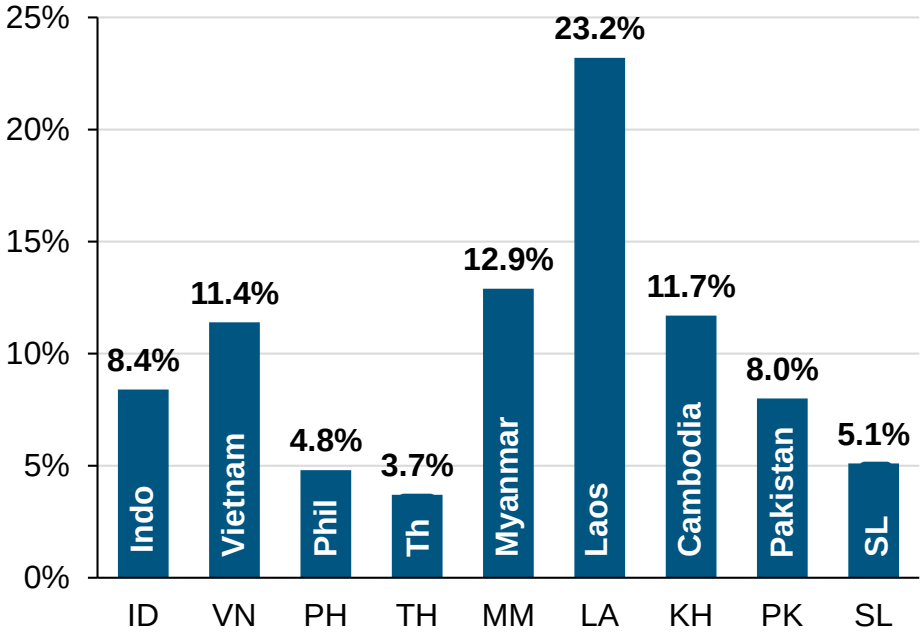
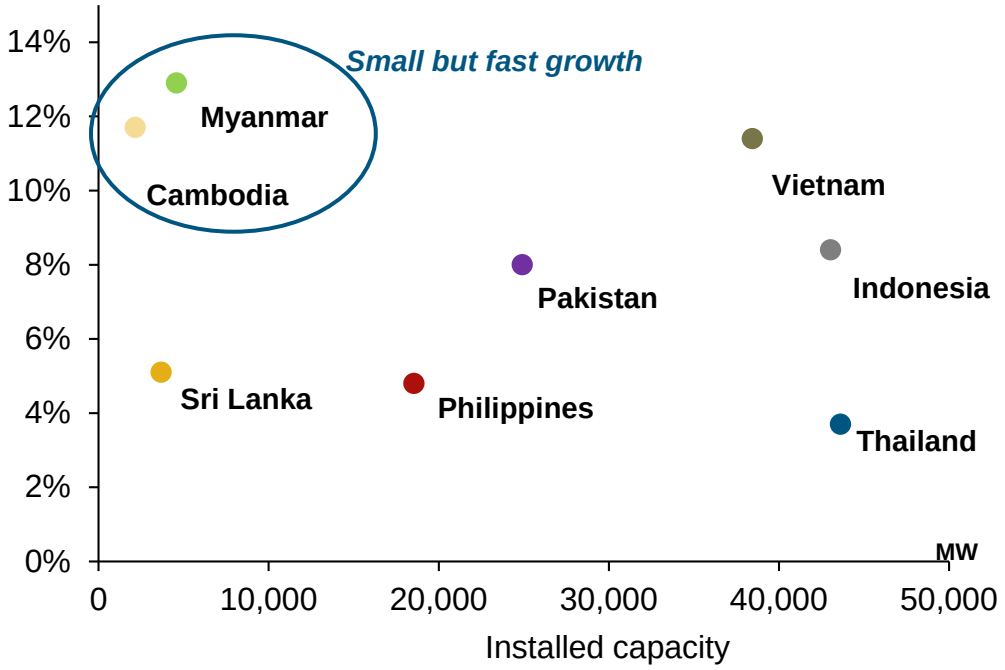
Demand growth in SE Asia remains high, particularly in the Mekong sub-region

- Demand growth is being spurred by industrialisation of developing economies.
- Countries with the highest rates of demand growth are typically those where increasing electrification is unlocking hitherto unserved demand.

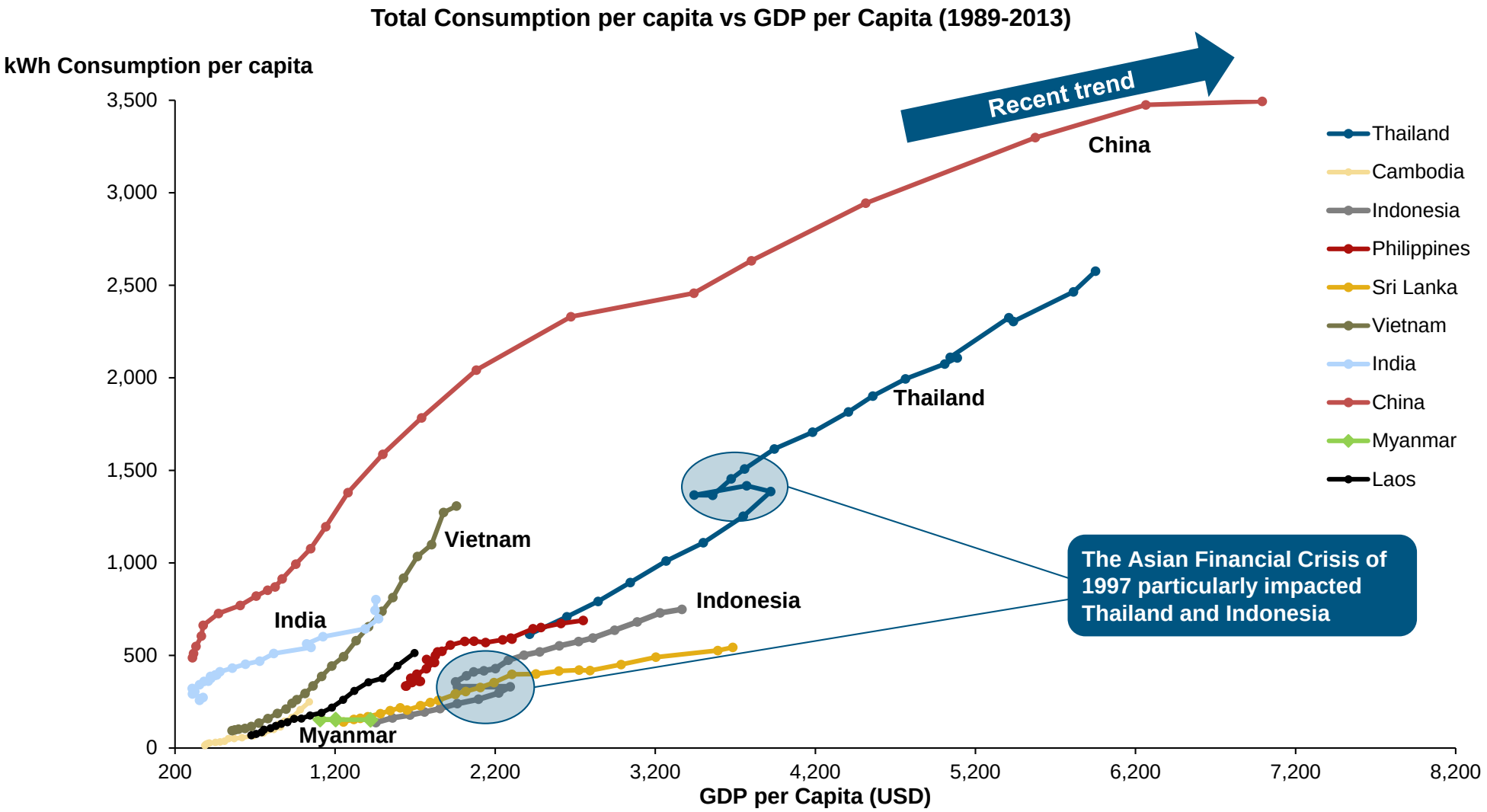
Forecast demand growth over the next 3 years (CAGR)



Demand growth forecast relative to 2015 installed capacity

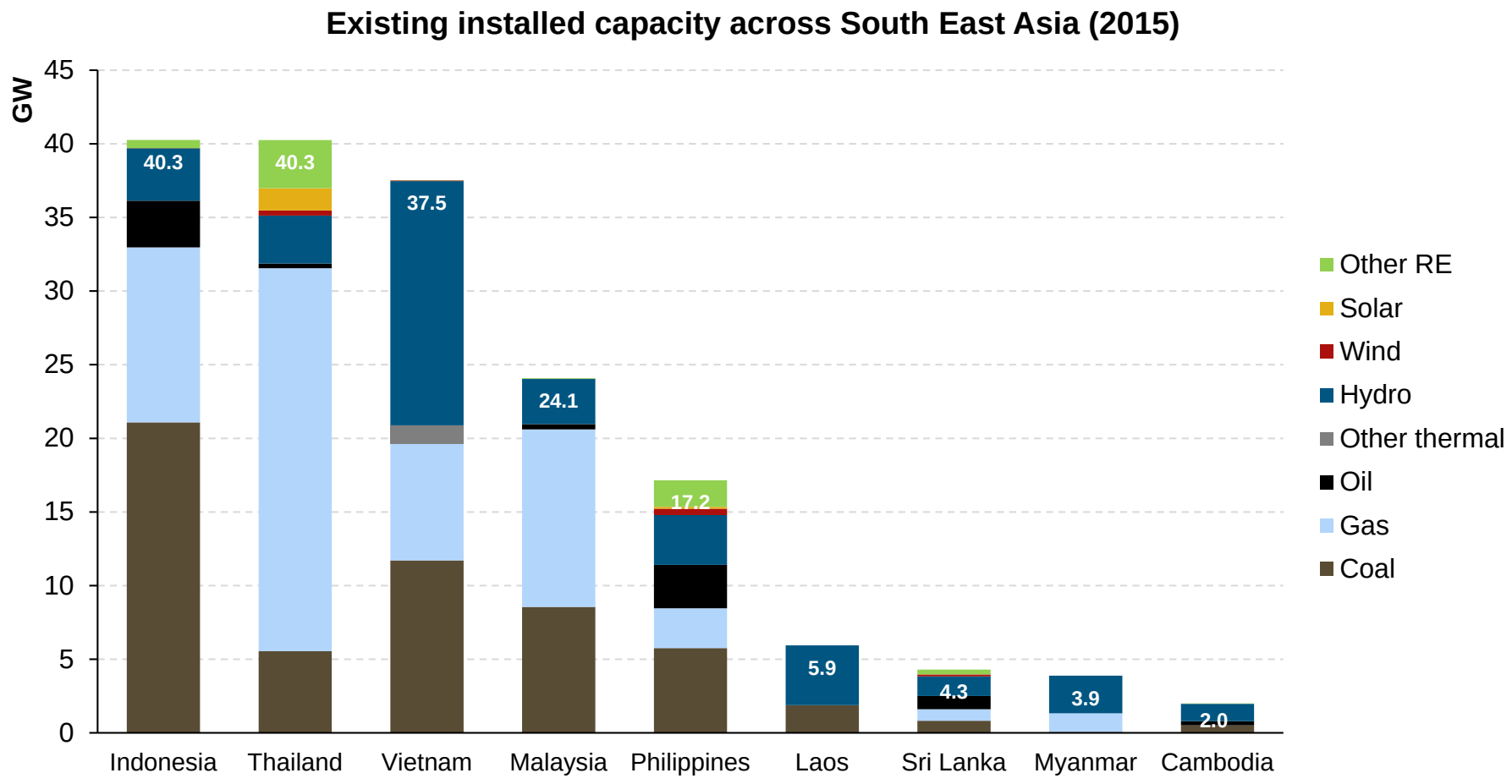


And whilst electricity consumption per capita will eventually reach saturation, the majority of SE Asia will remain on an upward trajectory for some time



Source: World Bank

Generation capacity across South East Asia to date has largely been driven by each countries' domestic fuel resources

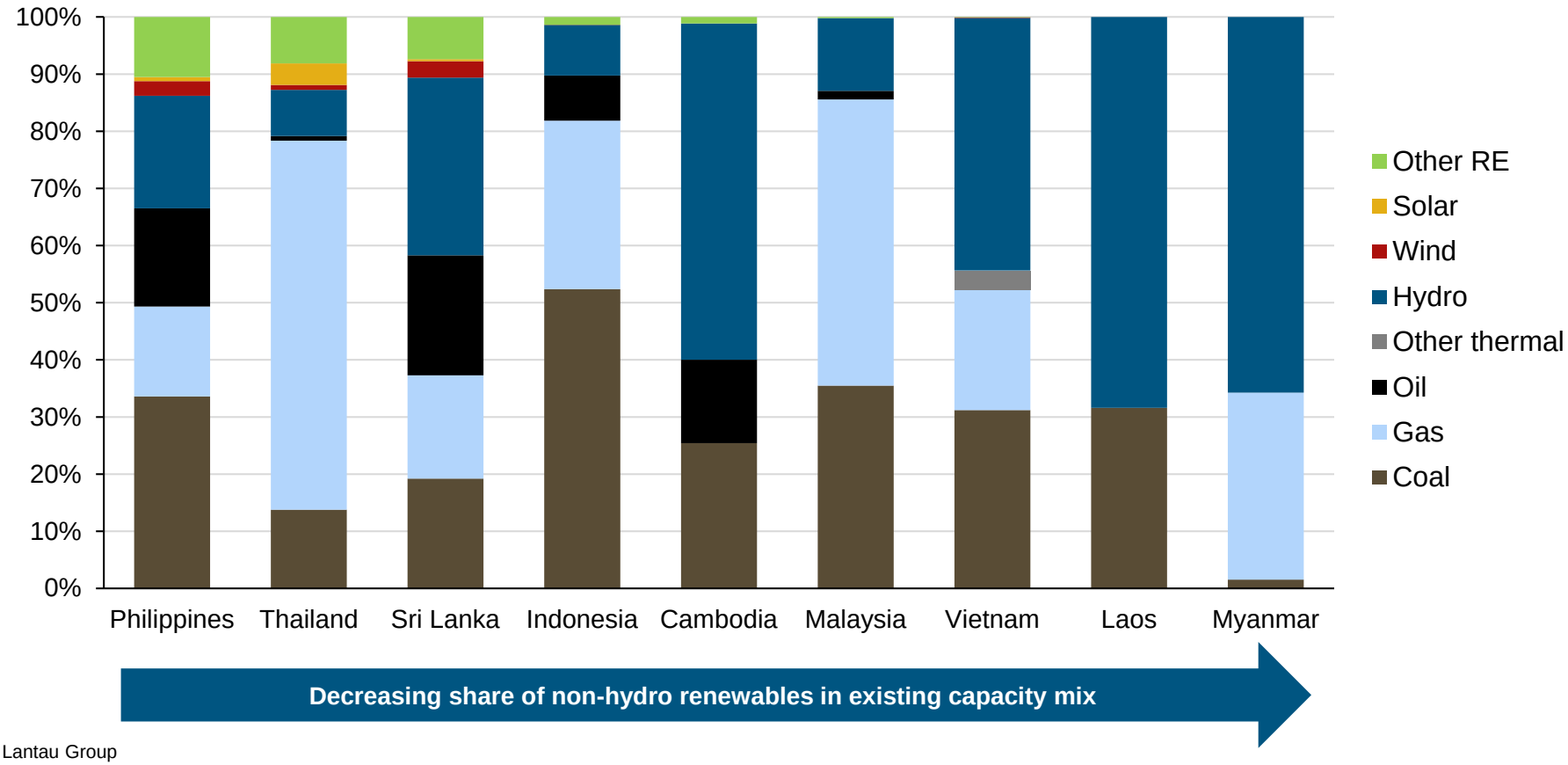


Note: All gas supply is imported in Singapore and about 25 percent of gas supply is imported in Thailand.

Renewables still represent a relatively small share of the overall generation mix

- Even in the Philippines, which is one of the most progressive countries for RE, solar, wind, and other forms of non-hydro RE account for just 13% of installed capacity.

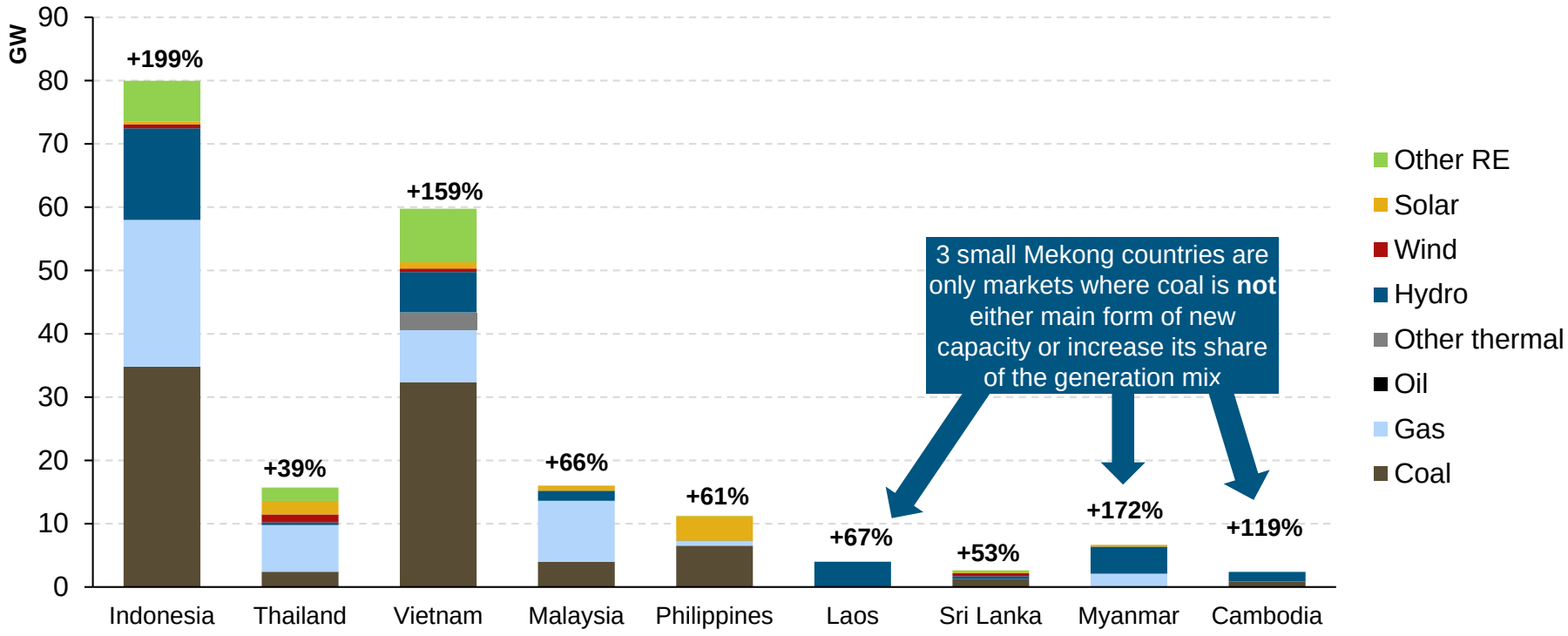
Percentage share of existing installed capacity across South East Asia (2015)



So where is the growth?

- Coal and gas continue to dominate, with capacity set to more than double in Indonesia and Vietnam.

Capacity additions across South East Asia, by technology (2016-2025*)

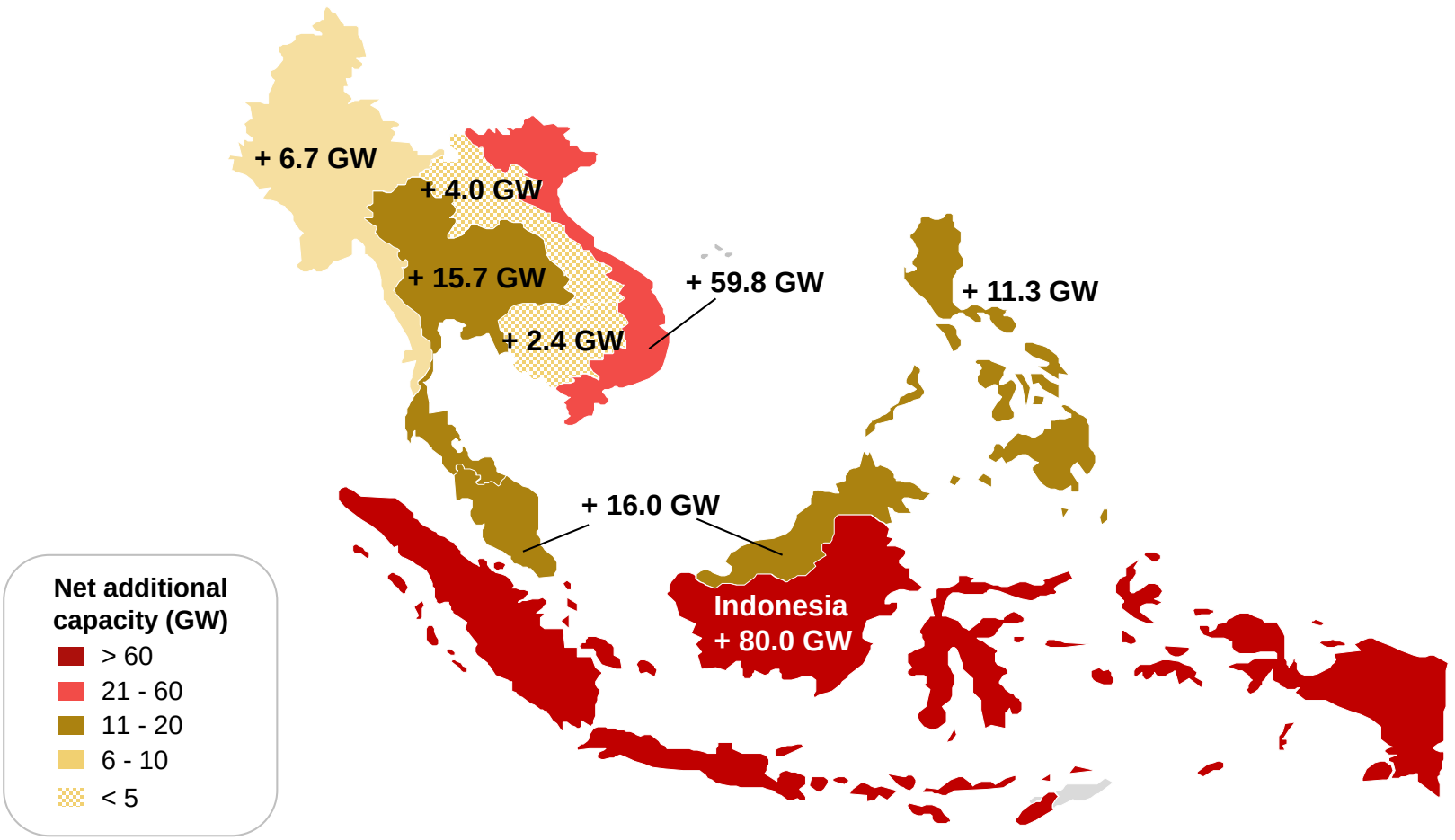


* Cambodia and Laos forecasts are only published through to 2020

Source: *Data reflects PDP and other official planning, except Philippines where forecasted capacity additions have been modeled using TLG market models.*

Over the next ten years, Indonesia and Vietnam dominate the growth outlook in absolute terms

Net capacity additions in South East Asia through to 2025



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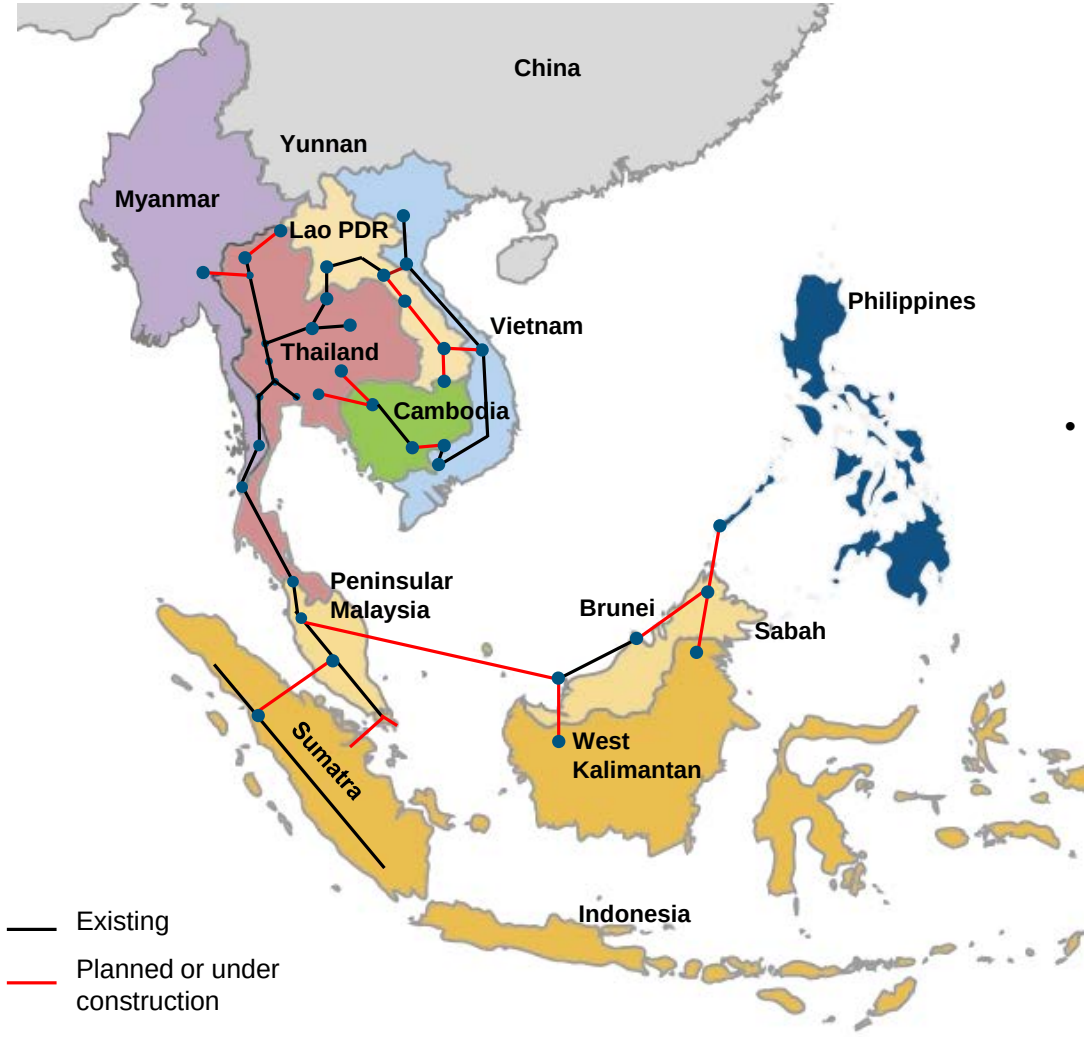
Future grid expansion and integration across the ASEAN region has the potential to influence capacity build…..

Existing and planned interconnections in ASEAN



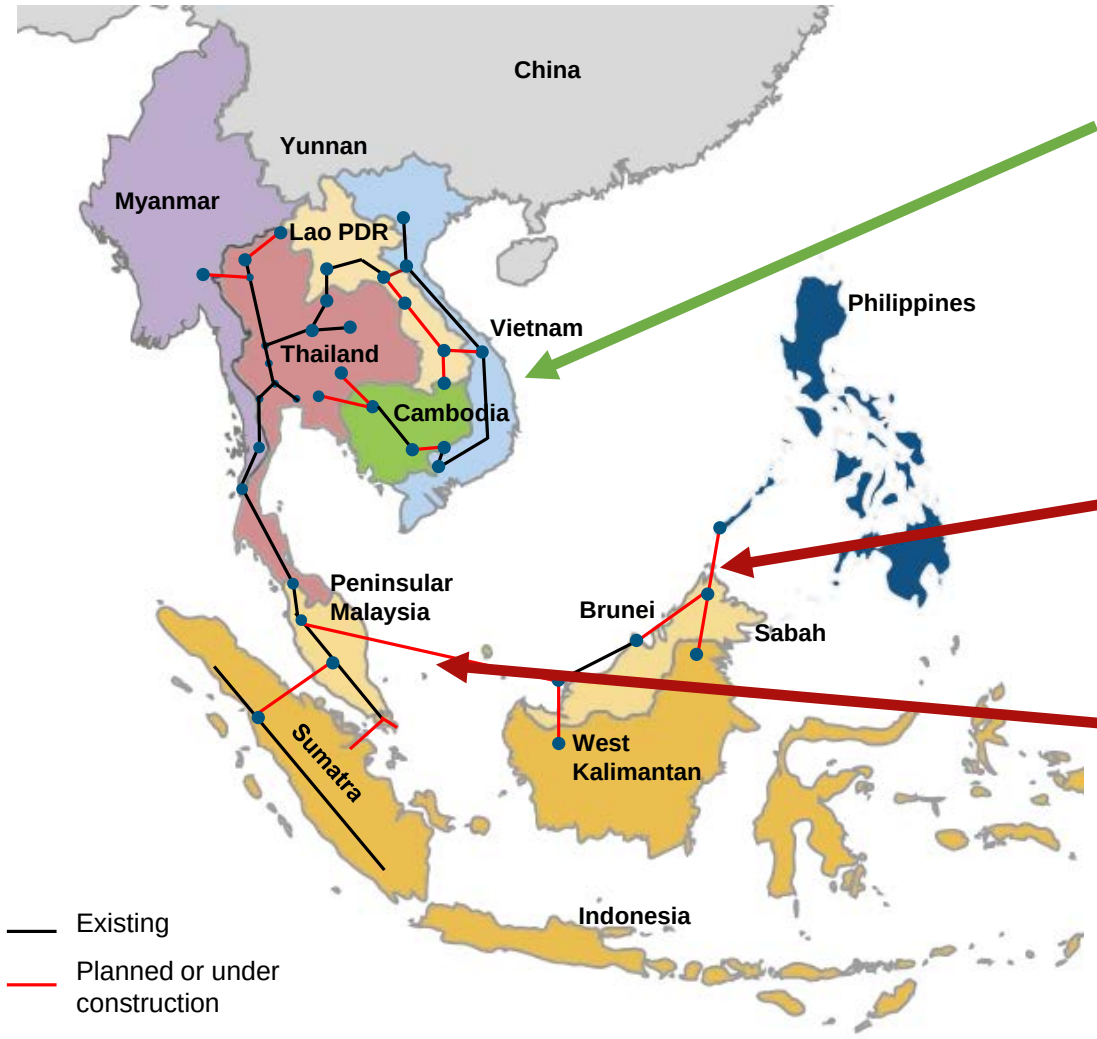
- The long-hailed ASEAN Power Grid (APG) seeks to improve the security and reliability of the region's power system, and provide a more economic and efficient mode of operation by:
  - Developing cross-border power transactions and flows
  - Optimising the diverse fuel resources across the region *(eg. Laos)*
  - Lower capex expenditure for future generation, due to non-coincident demand peaks across the region
- Timeframes for implementation and a commercial framework are unclear however and may be a long way off.

Near Term Projects	Future Projects *2020 onwards*
• Additional 10 cross-border interconnections • 7,192 MW of total capacity	• Additional 17 cross-border interconnections • 25,424 MW of total capacity

Source: HAPUA as of November 2015

… but in practise this is likely to be limited to countries that are close together, probably with land borders

Existing and planned interconnections in ASEAN



Links within the Mekong region are relatively cheap and connect generation hubs to demand centres – they make economic sense and thus are likely to continue

Sabah to Palawan makes no sense – the peak demand in Palawan is less than 30MW and it is not interconnected with the rest of the Philippines!

Sarawak to Peninsular Malaysia is within a single country, yet the economics of this line make it very hard to justify

Source: HAPUA as of November 2015

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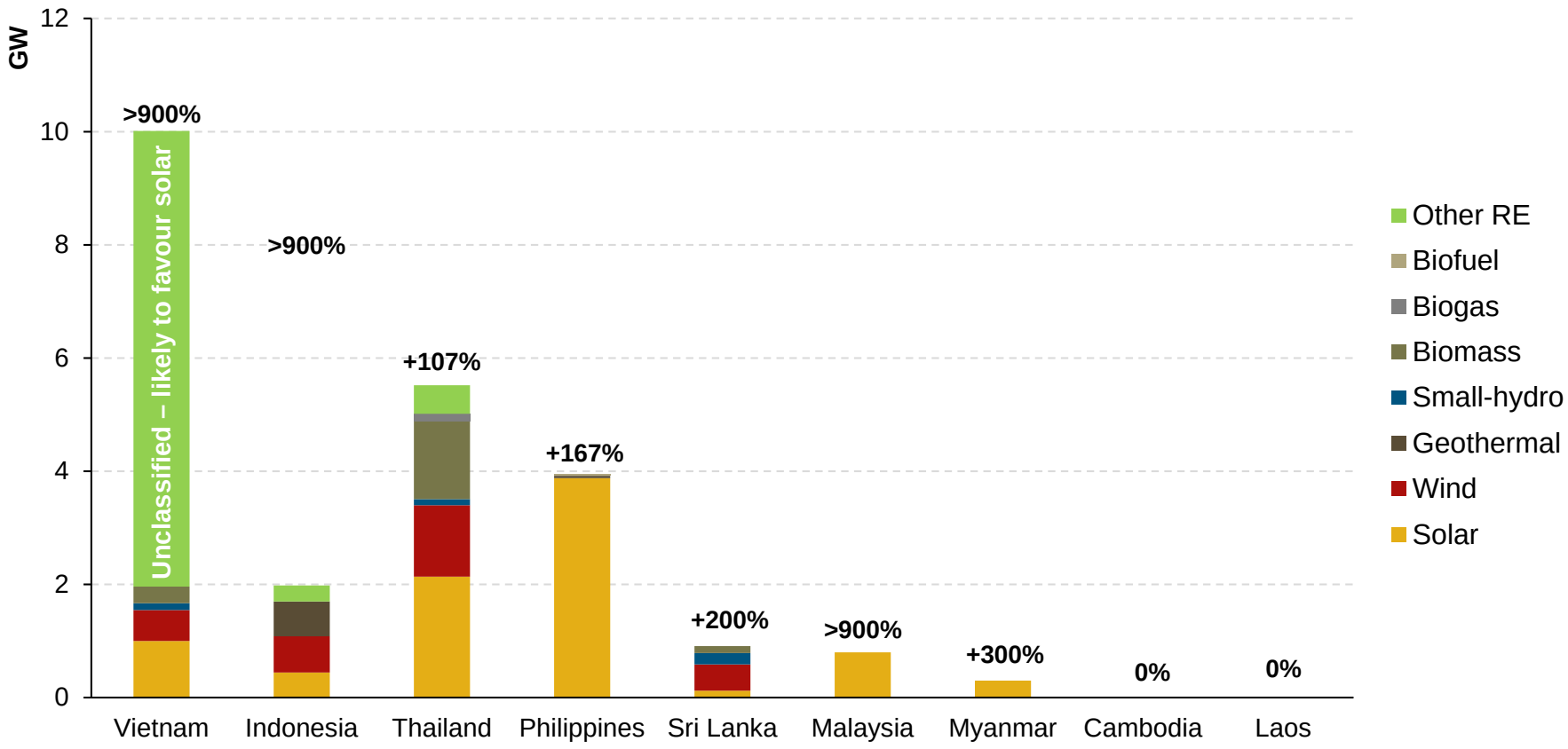
Regional plans are slowly pivoting towards RE, with solar and wind expected to dominate the mix of RE technologies

Renewable energy capacity additions across South East Asia, by technology (2016-2025*)



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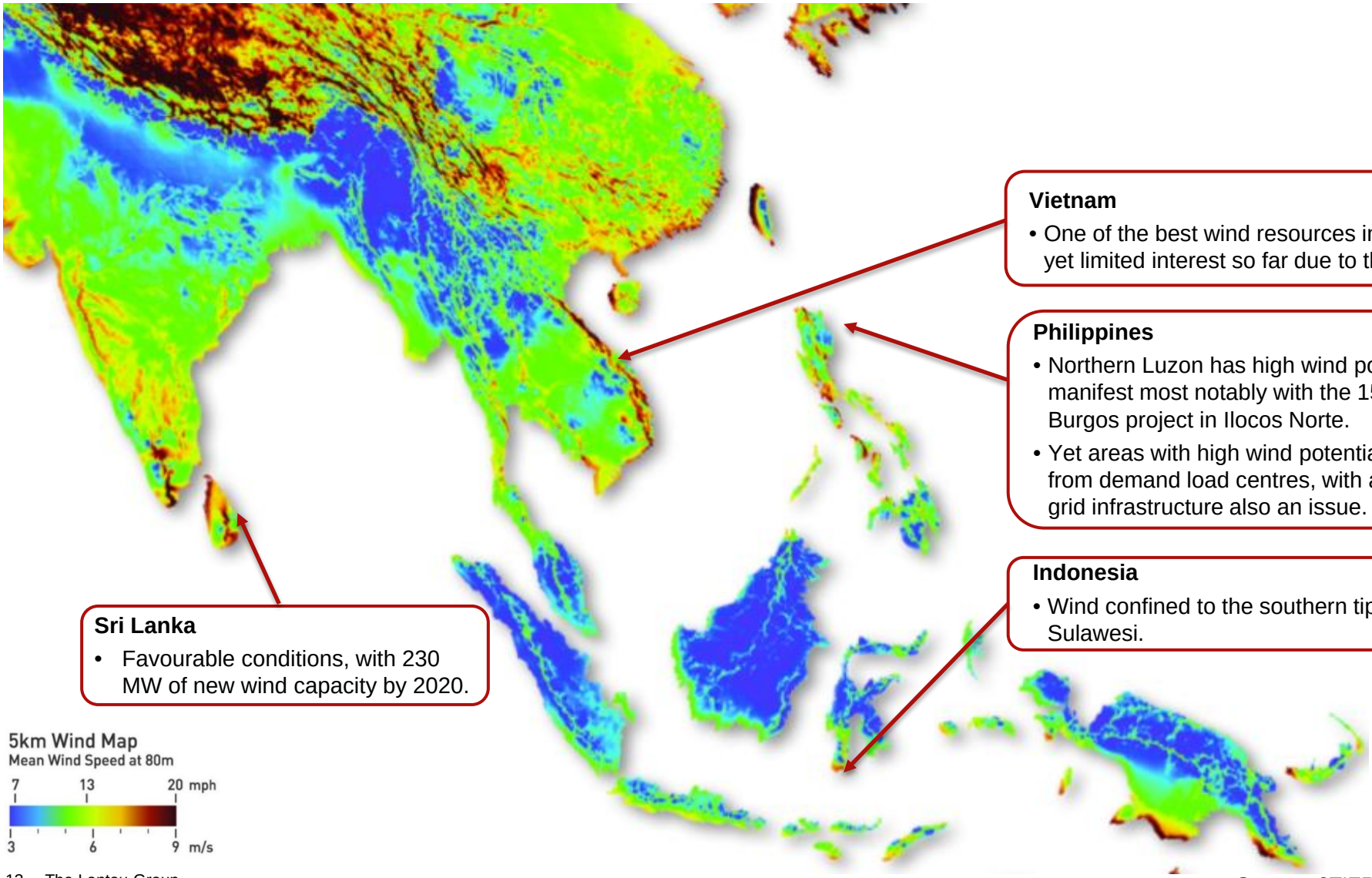
Wind resources in SE Asia do not typically favour the development of utility-scale projects, although there are some some exceptions



Vietnam

- One of the best wind resources in SE Asia, yet limited interest so far due to the low FIT.

Philippines

- Northern Luzon has high wind potential, manifest most notably with the 150 MW Burgos project in Ilocos Norte.
- Yet areas with high wind potential are far from demand load centres, with a lack of grid infrastructure also an issue.

Indonesia

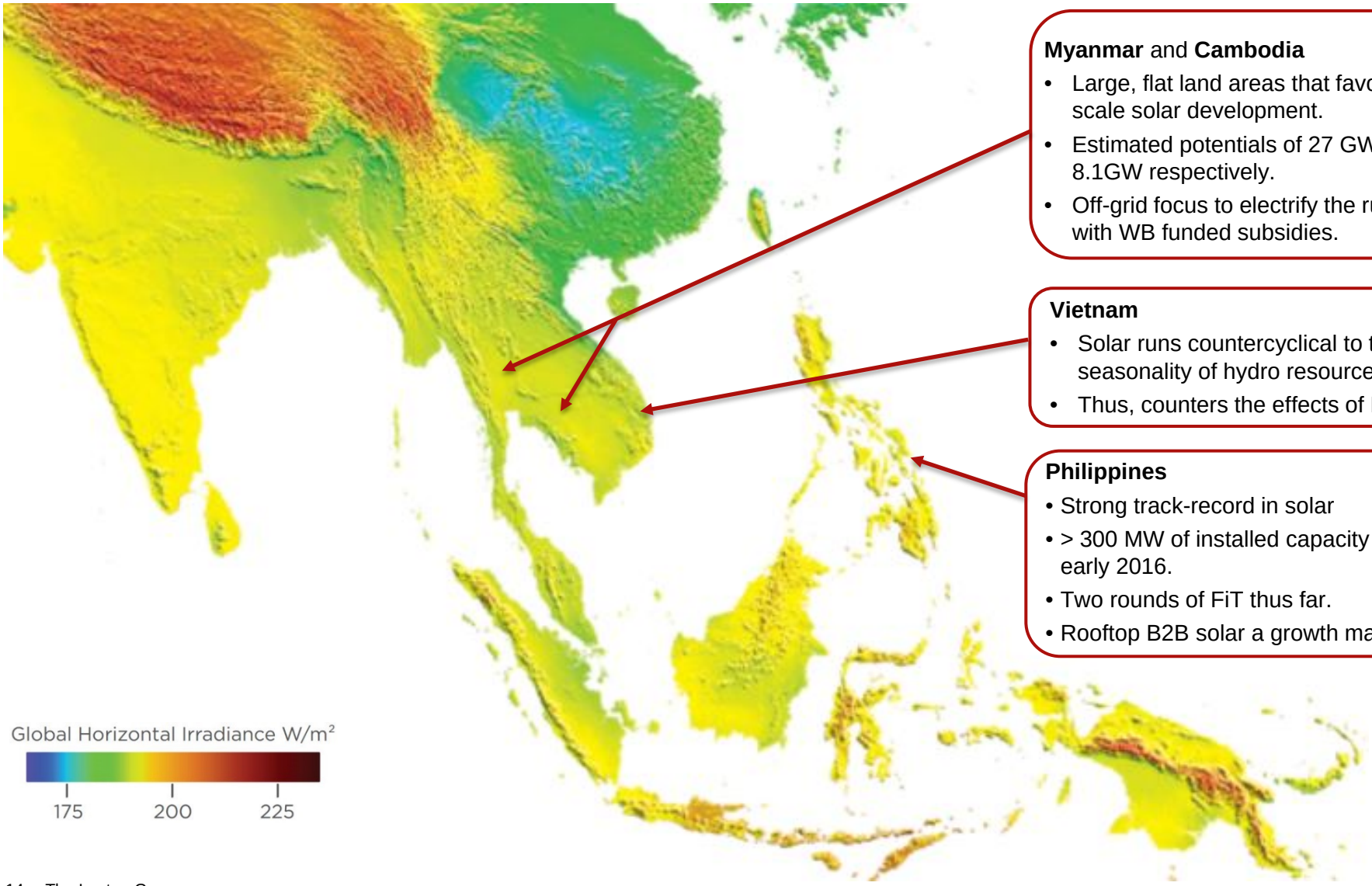
- Wind confined to the southern tip of Sulawesi.

Sri Lanka

- Favourable conditions, with 230 MW of new wind capacity by 2020.

Source: 3TIER Inc.

However from a resource perspective, solar generation in South East Asia is highly favourable, albeit with country-specific nuances



Myanmar and **Cambodia**

- Large, flat land areas that favour utility-scale solar development.
- Estimated potentials of 27 GW and 8.1GW respectively.
- Off-grid focus to electrify the rural area, with WB funded subsidies.

Vietnam

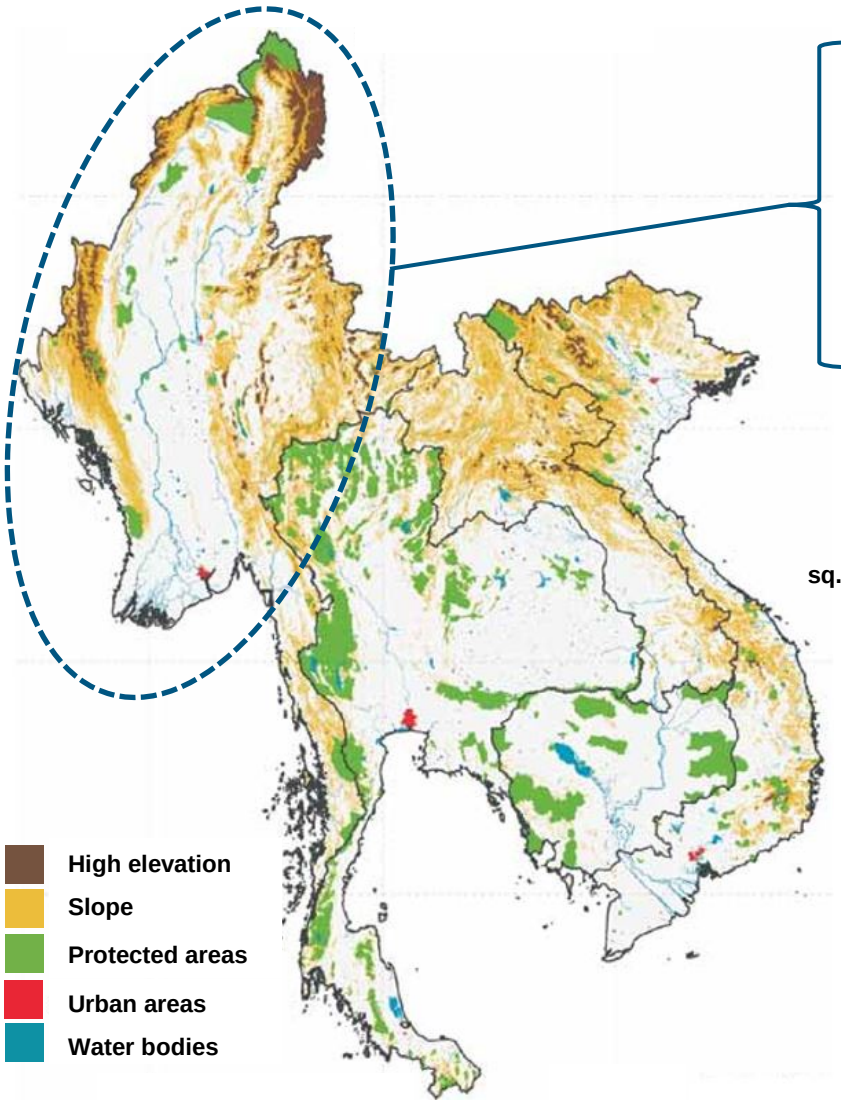
- Solar runs countercyclical to the seasonality of hydro resources
- Thus, counters the effects of El Nino

Philippines

- Strong track-record in solar
- > 300 MW of installed capacity as of early 2016.
- Two rounds of FiT thus far.
- Rooftop B2B solar a growth market.

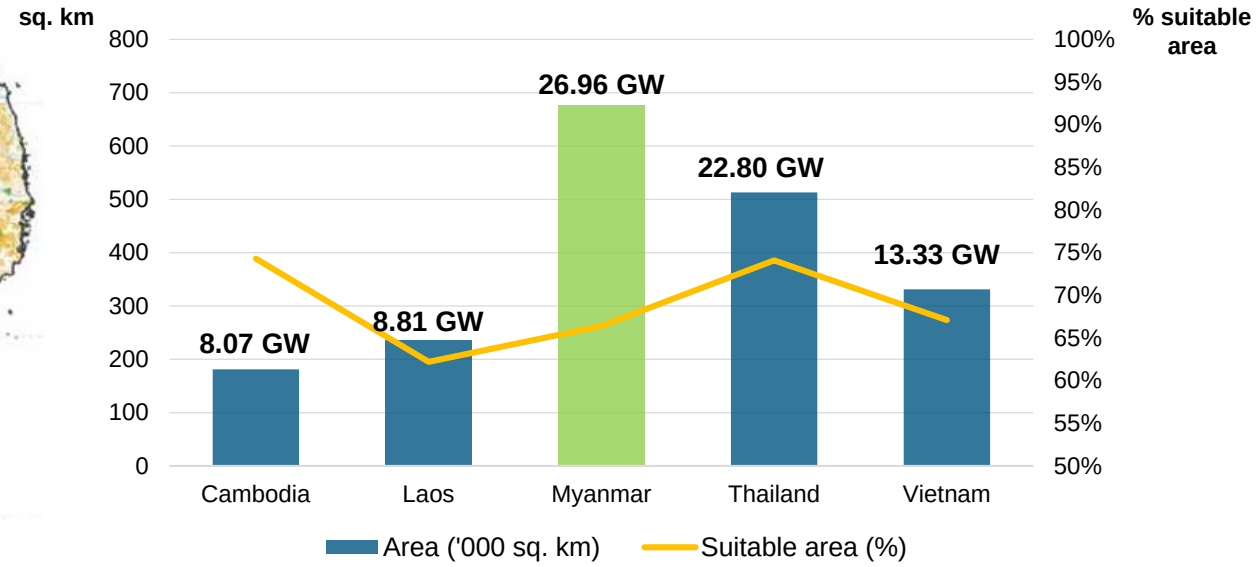
Source: ADB; Vaisala Inc.

Specifically in Myanmar offers one of the highest potentials for solar development, with favourable topography and low electrification rates



- Myanmar is the largest country in SE Asia, and well-suited to solar due to the relatively low proportion of upland areas.
- Whilst there is already significant inward investment in solar through off-grid generation schemes such as SHS, utility-scale projects are also attractive from a resource perspective.
- Notable projects include:
  - Mandalay Solar (2 x 150 MW), 30 year PPA @ $0.1275 / kWh
  - Ayeyarwady Solar, (300 MW), MOU signed

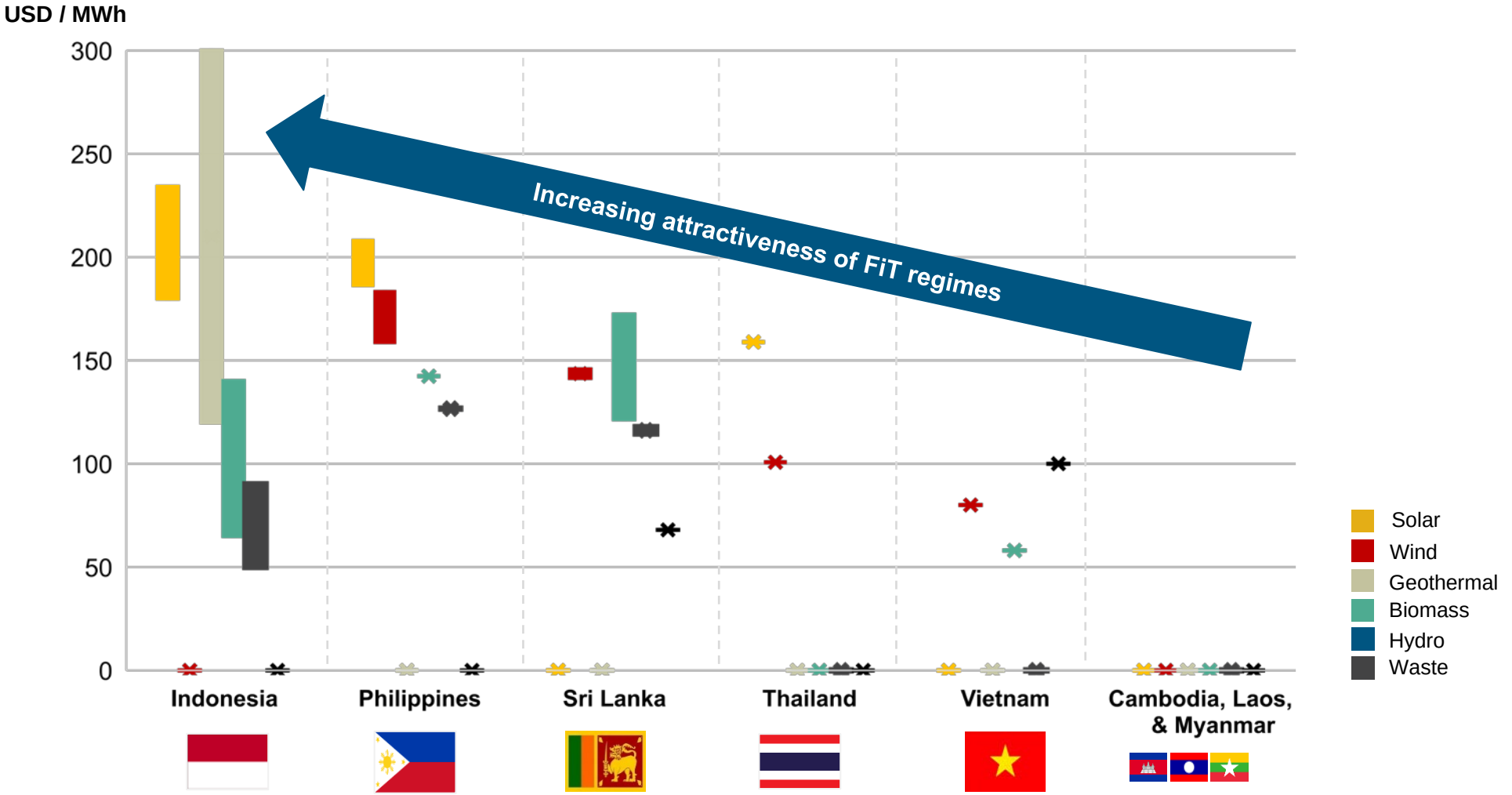
Solar potential across selected ASEAN nations



Source: ADB; GeoModel Solar s.r.o

In several nations, RE has been given a ‘kick-start’ at the policy level via a FiT, however quotas are generally limited and affordability concerns persist

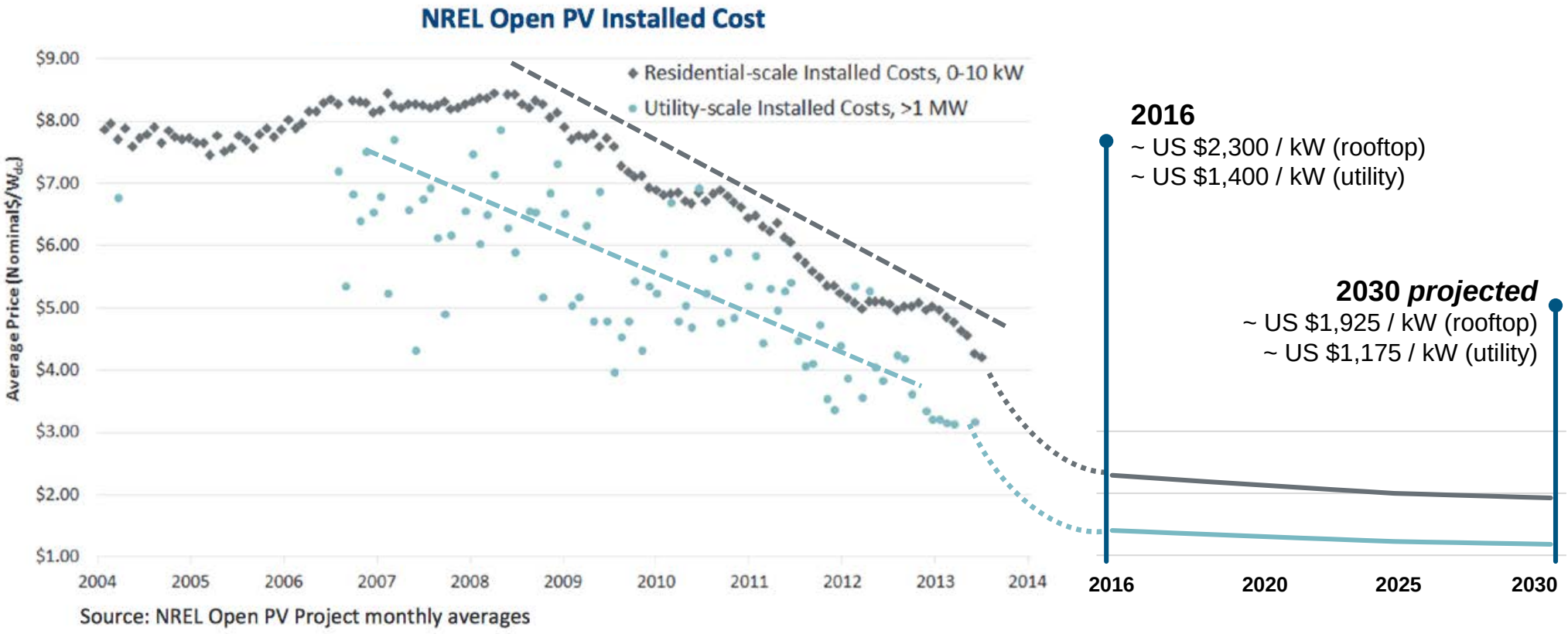
Regional comparison of FiT incentives by technology



* FiTs per technology vary according to size, location, and local content, amongst other factors

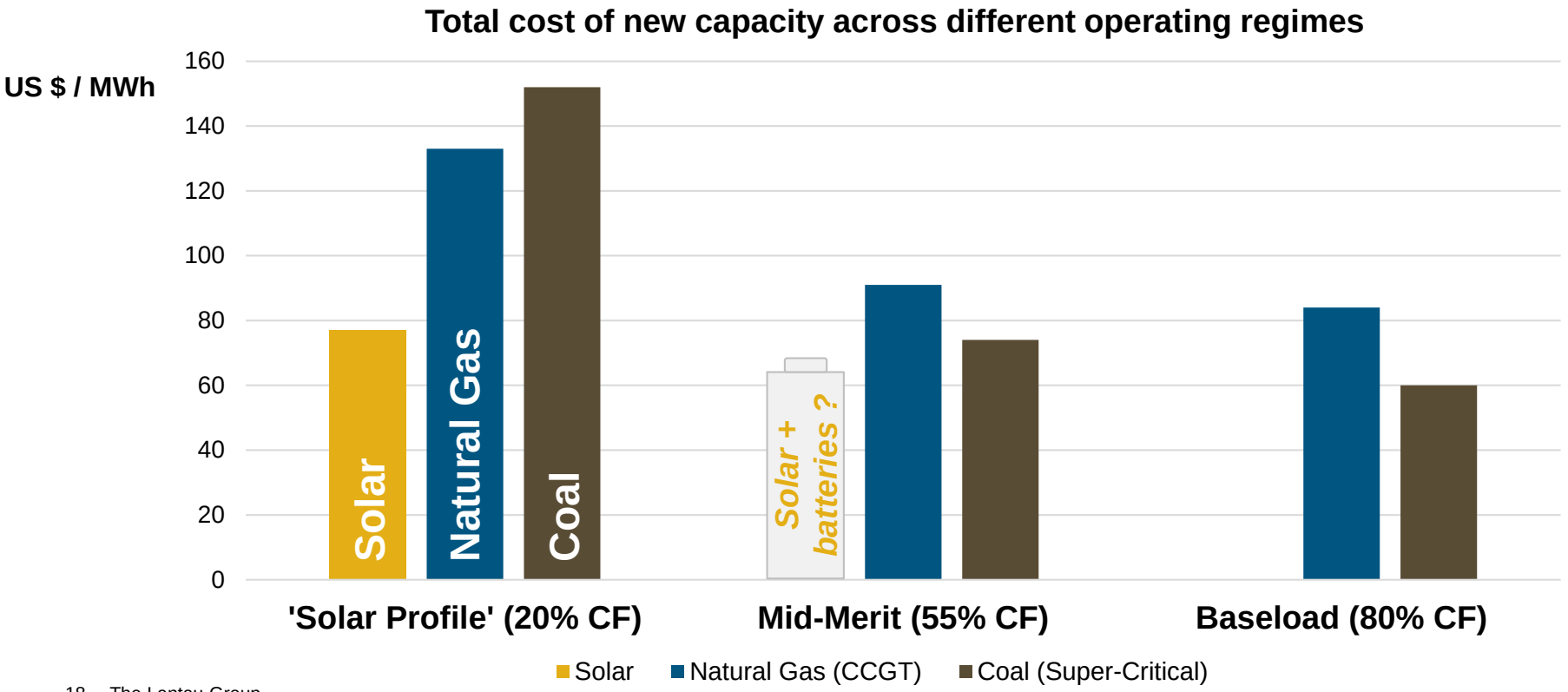
Nevertheless, falling costs for solar are making the economic case for solar increasingly compelling…

- Solar costs have been on a clear downward trajectory for the past 8 to 10 years, a trend which is modestly expected to continue to fall

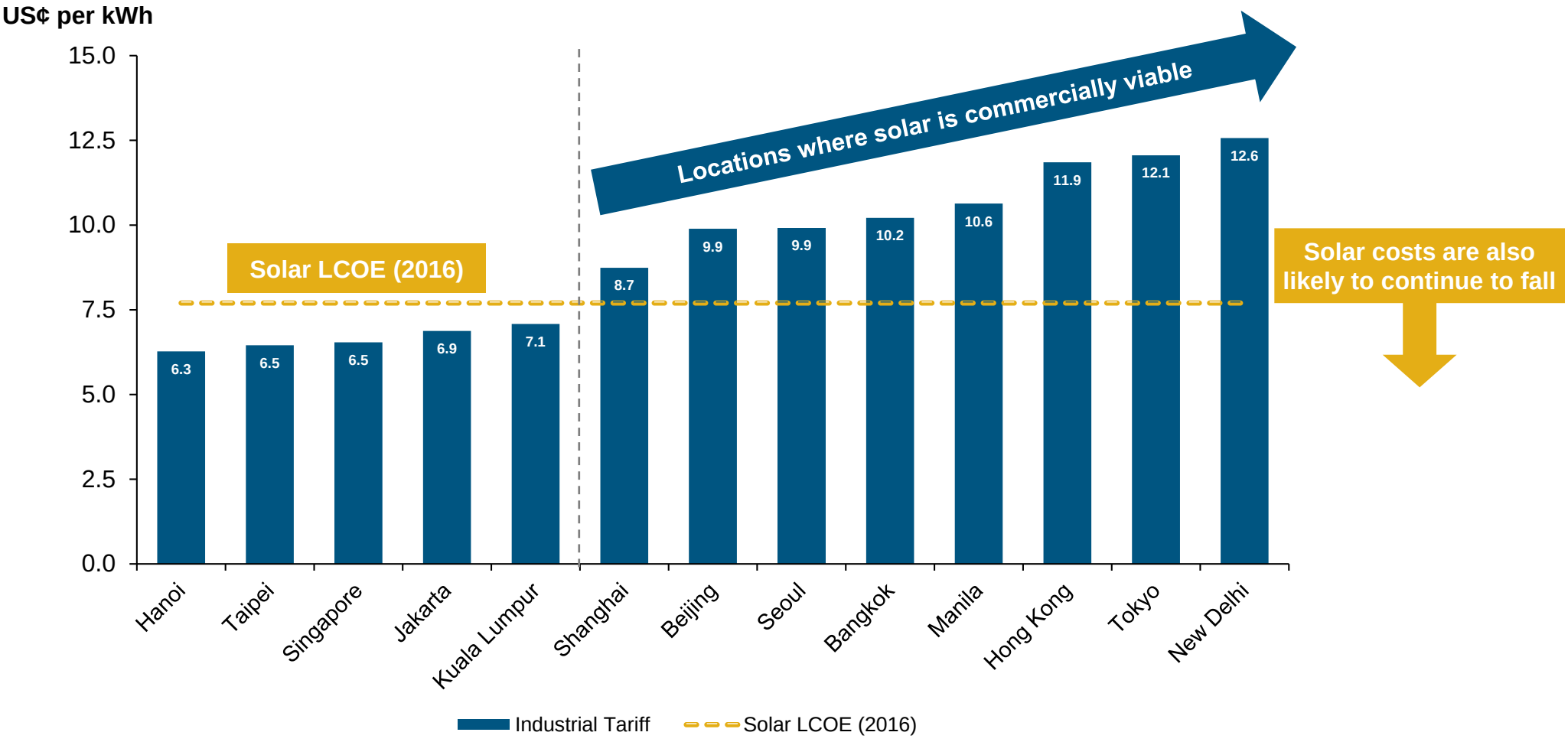


… Which has resulted in solar competing head-to-head with gas-fired generation to serve peak demand

- The economic entry of solar is increasingly viable and, compared against natural gas, is highly competitive in a peaking application.
- Looking forward, the advent of ‘solar-plus-battery’ systems on a commercial basis is likely to further disrupt the status quo.



And when compared against prevailing tariffs, solar is becoming increasingly commercially viable in a number of Asia cities, even without the need for a FiT

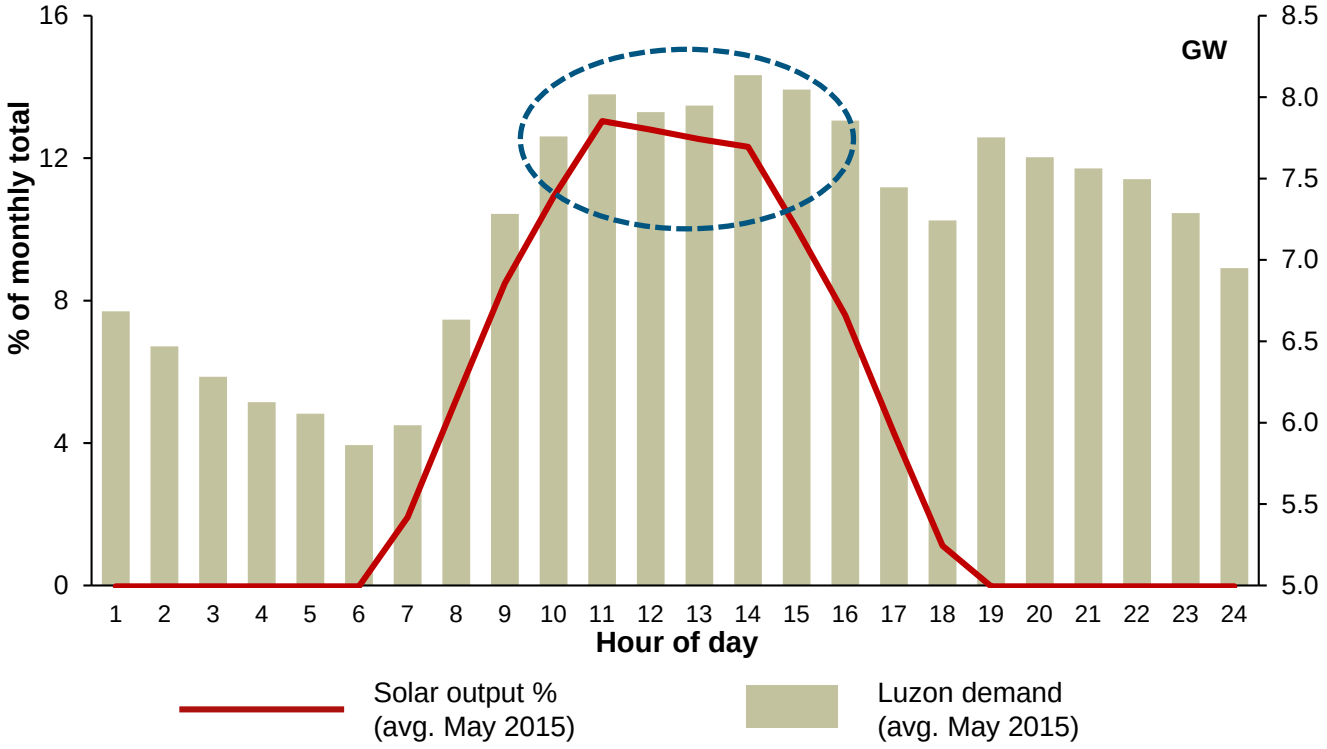


Source: TLG research based on published tariff of franchised / dominant retailer serving the metropolitan area of the city

The attractiveness of solar is further bolstered by the natural tendency for solar output to be able to capture higher prices during peak hours

Philippines case study

Hourly solar generation and demand in the Philippines (Luzon)



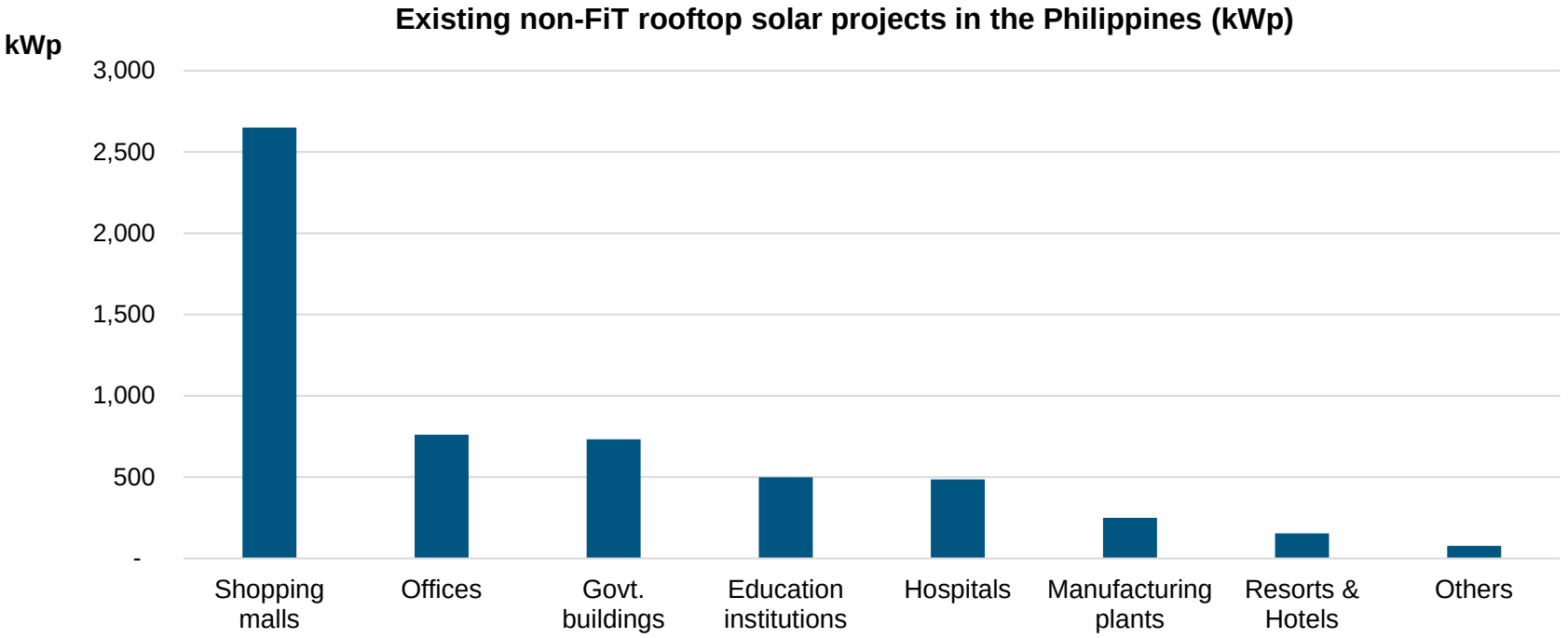
- On average, there is a strong alignment between average peak demand and the solar generation profile.
- As a result, solar is typically able to capture the most profitable hours.

Source: PEMC; TLG analysis

In addition to utility-scale solar, rooftop solar is increasingly gaining traction

Philippines case study

- In the Philippines, existing capacity for rooftop solar is close to 50 MW.
- Capacities are small, and whilst 43 MWp of rooftop solar has been developed with the support of a FiT, in excess of 6 MWp has been developed on a purely commercial basis.
- Most rooftop solar has been built over the past two years, underscoring the infancy of this market.



* Note: This data may be incomplete due to small rooftop solar projects that have not been publicly announced

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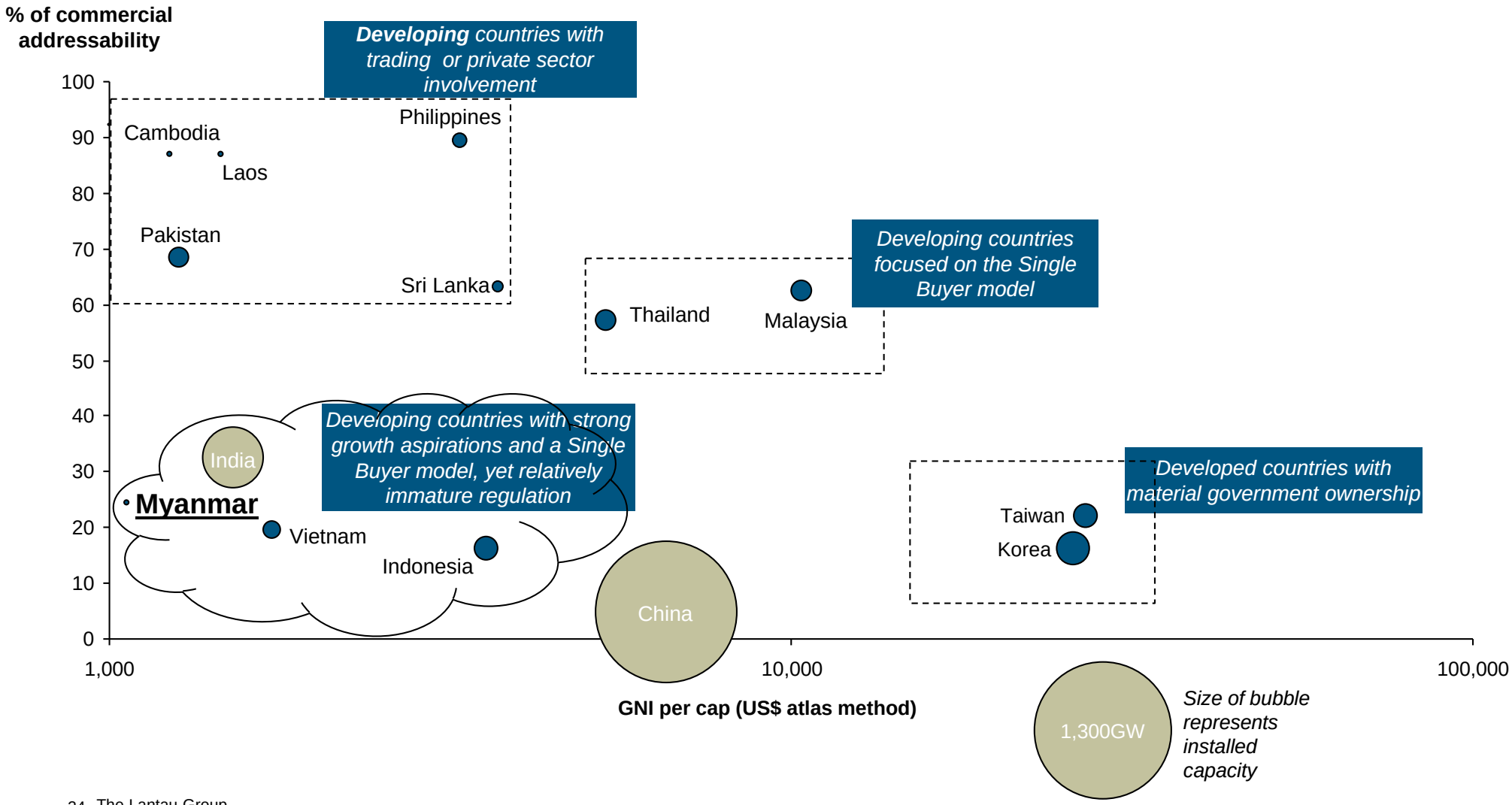
An overview of Myanmar's power sector

Installed capacity *2016*	4,481 MW
Peak demand *2016*	2,592 MW
Electricity consumption *2016*	15,975 GWh
Generation fuel mix *2014*	Hydro: 64% Natural Gas: 32% Coal: 3%
Reforms	Electricity Act (1948, rev. 1967) Electricity Rules (1985) Foreign Investment Law (2012) Electricity Law (1984, rev. 2014)
Wholesale / Retail market	No plans
Independent regulators	Ministry of Electric Power; Electricity Regulatory Commission
Consumption per capita ***2015***	127.3 kWh
Electrification ***2015***	32% of households

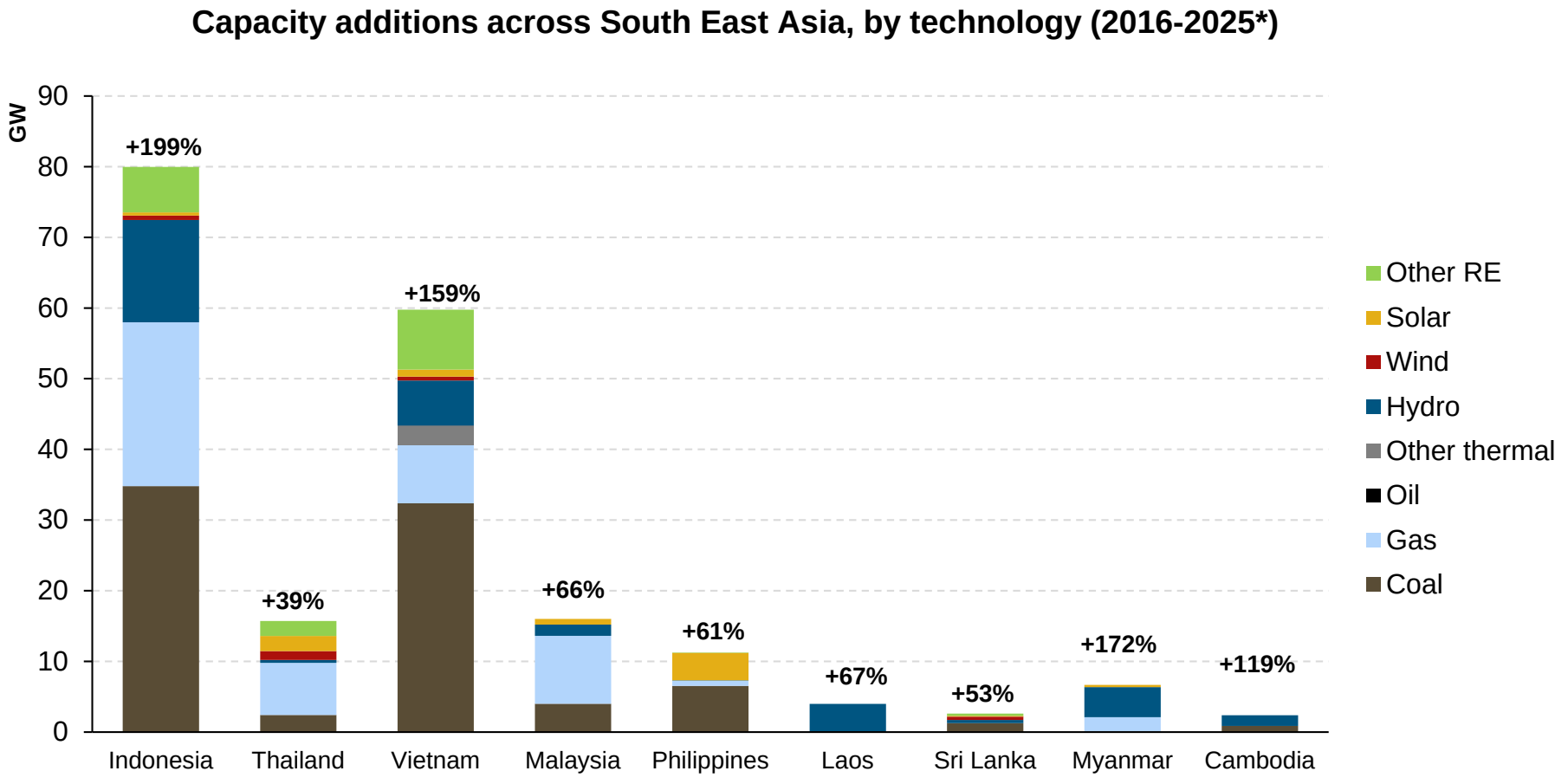
Source: MOEP; NEMC Myanmar; TLG analysis

Which trajectory will Myanmar take?... Nations across SE Asia operate diverse market models, with Myanmar at the nascent stages of its journey



Source: World Bank; TLG analysis

Capacity additions in Myanmar appear set to buck the broader regional trend for coal…



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... Although uncertainty persists, particularly regarding availability of “fuel”

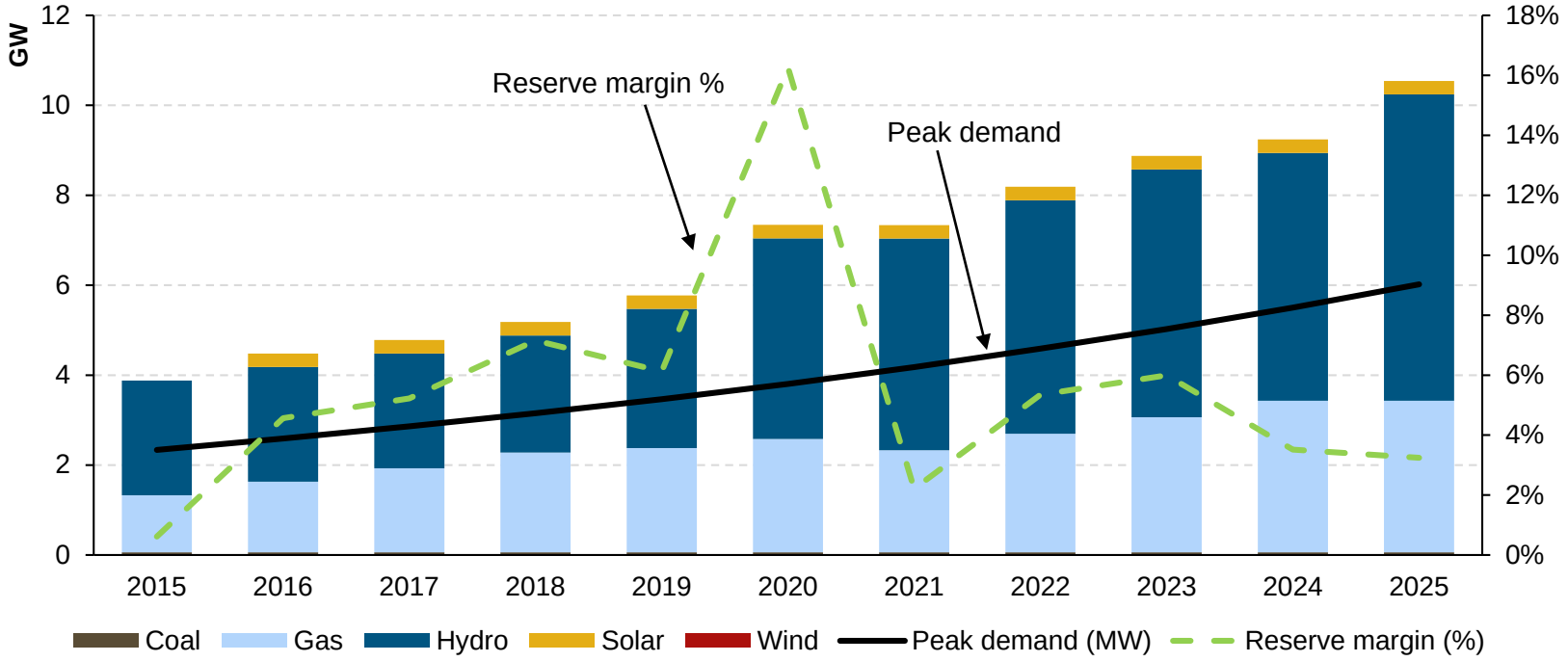
- Hydropower has historically been the mainstay of Myanmar’s generation mix, however it is prone to seasonal variation.
- Uncertainty regarding future plant build persists, although coal appears out of favour and hindered by:
  - Local opposition and the role of Civil Society Organisations
  - A lack of resource availability and infrastructure for import / transportation
  - WB moratorium on funding with calls for JICA to follow suit
  - No real precedent to date
- Meanwhile gas-fired generation is set to increase from its current installed capacity base of around 1.2 GW, although the size of units (200-250 MW) will likely remain constrained by fuel availability and transmission infrastructure:
  - Notable projects include Myingyan near Mandalay (CoD 2018) and Kanbauk/Dawei (CoD 2020).
  - MoEP itself has voiced concerns over the availability of natural gas for natural gas.
  - Declining offshore field output is tempered by some new discoveries being made (A6 / AD7).
  - Is LNG on the horizon?

The crossroads at which Myanmar stands presents considerable challenges for generation planning, yet also considerable opportunity

Supply-demand balances are expected to remain acutely tight for the foreseeable future, and prone to seasonal fluctuations in hydro

- Against a backdrop of robust demand growth, reserve margins are expected to remain tight in the short to medium term, with a short-lived spike upwards in 2020 due to the addition of the Shweli 3 hydro project.
- The large weighting of hydro in the installed capacity mix, currently around 66%, makes Myanmar particularly vulnerable to seasonal fluctuations in rainfall and river flows.

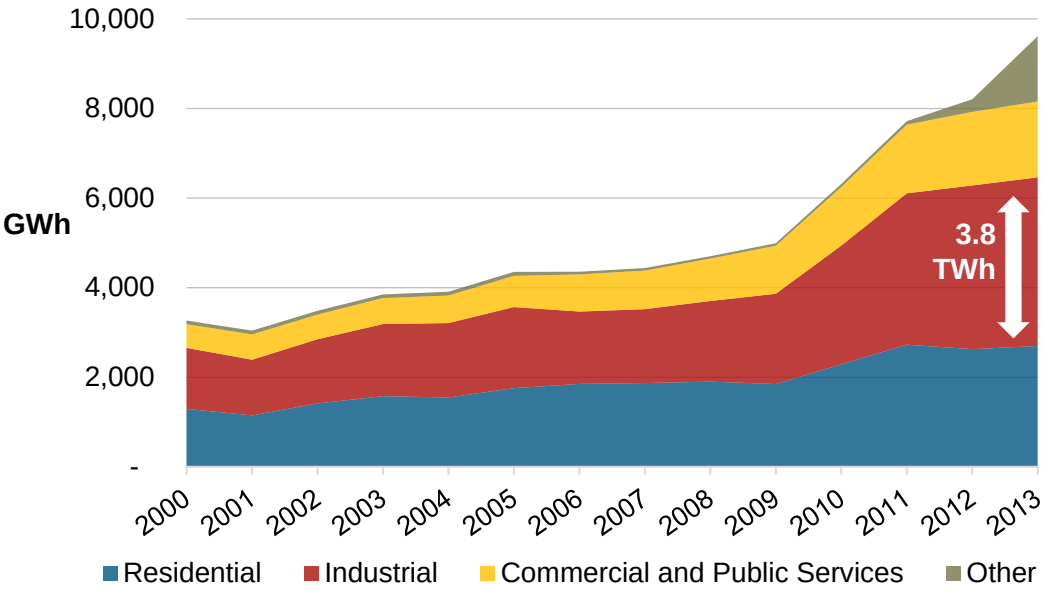
Myanmar: Installed capacity, peak demand, and reserve margins



*Note: To account for seasonality and physical constraints, the reserve margin calculation assumes a 40% capacity factor for hydro, and 20% for other forms of RE.
Source: MOEP; TLG analysis

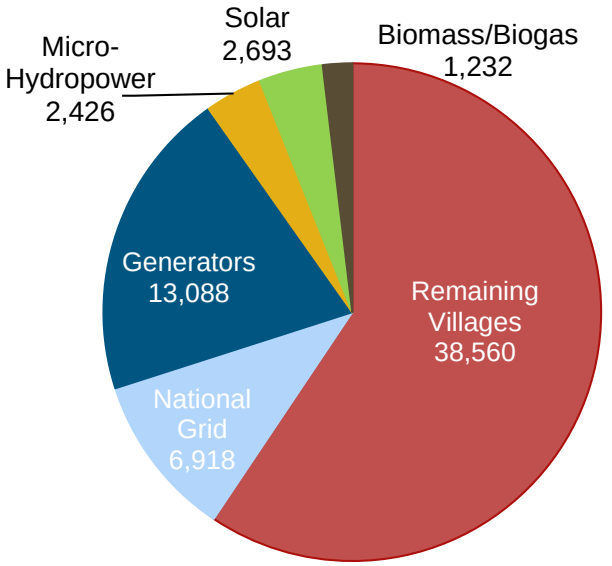
But Myanmar's demand is characterised by two markedly different stories: rampant industry-led demand growth, yet substantial latent demand

Robust electricity demand growth led by industry



- Electricity consumption has more than doubled between 2006 and 2016, and grown at a average annual rate of 13.6% over the last five years.
- Growth underpinned by a strengthening economic outlook and growth in Myanmar's transmission infrastructure.
- Industrial demand has grown at 15.1% pa. since 2010.

In rural areas there is substantial unserved demand



Electrification status of Myanmar's 64,917 villages *(2015)*

- Two-thirds of Myanmar's population of 53 million live rurally.
- Electrification stands at around 32% of households, with ~ 38,000 of 65,000 villages lacking access to electricity.
- Myanmar's HV transmission network is largely confined to the Yangon–Mandalay corridor.

Source: MLFRD, cited by CSIS (2015); NEMC Myanmar; TLG analysis

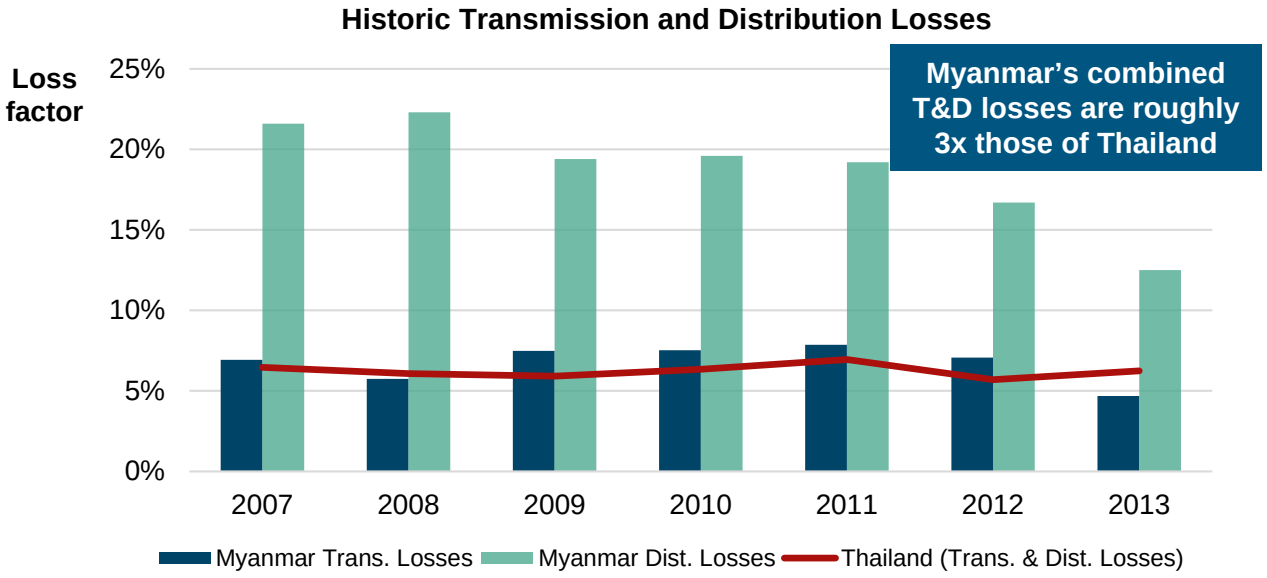
Whilst a key pillar of Myanmar's economic agenda sets out to achieve universal access to electricity by 2030, such a program is highly challenging

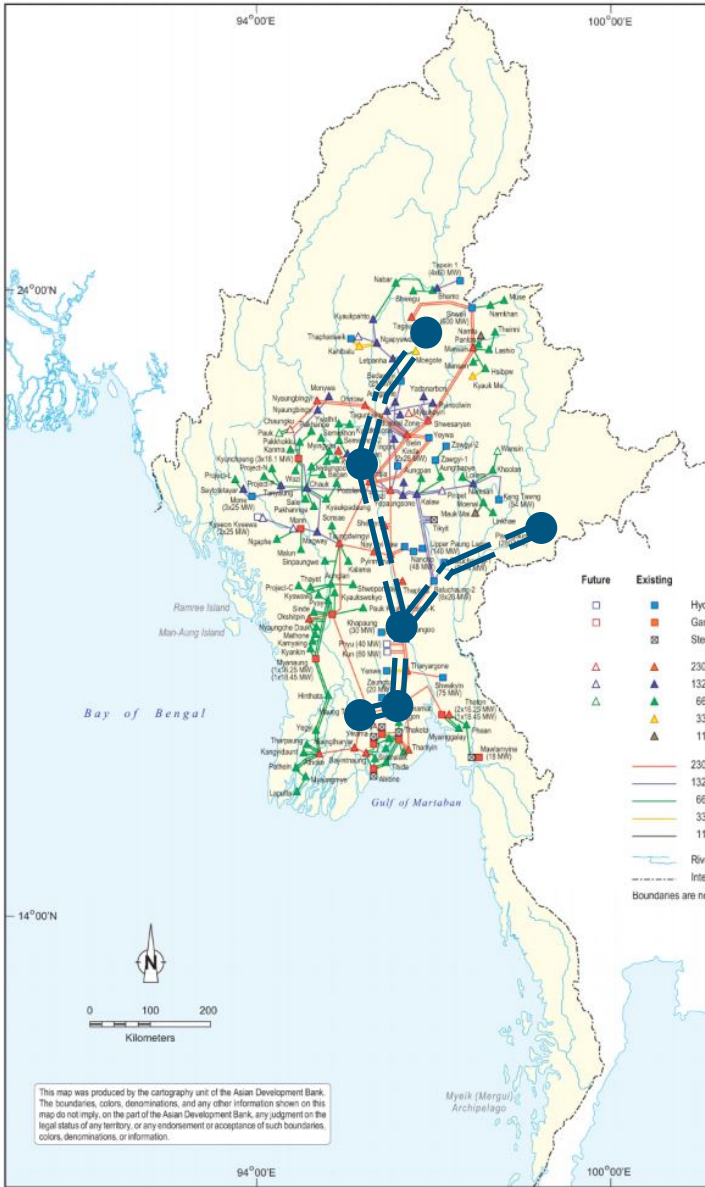
- National Electrification Plan (NEP), developed by MoEP and MLFRD and supplemented by:
  - An Energy Master Plan for primary energy sources
  - A Power Sector Master Plan for generation and transmission
- The Government has set out an ambitious goal for universal electricity access by 2030, equating to around 7 million households.
- This would necessitate around 500,000 new connections pa., whereas only around 200,000 new residential connections are being made currently each year.
- The inherent financial and practical challenge of course stems from around two-thirds of Myanmar's population residing in dispersed, rural locations, a large proportion of which falls outside of the Yangon-Mandalay corridor:
  - With no established local distribution companies to lead the installations
- 'Least-cost' electrification will instead combine grid extensions with off-grid (pre)electrification.
- Grid, mini-grid, or off-grid?

Source: MoEP; World Bank

Several projects are afoot to improve the grid's fragility, helping to overturn significant transmission losses and in turn supporting further capacity additions

- Transmission projects are largely focused on strengthening the corridor between Yangon-Mandalay, and to the hydro assets in the North. Five core 500 kV projects:
  - i) KamarNat-MyaungTagar, 50 miles *(Proposed)*
  - ii) Taungoo-KamarNat, 117 miles *(Proposed)*
  - iii) MongTon-Taungoo, 230 miles *(Proposed)*
  - iv) ThaPyaWa-Taungoo, 153.3 miles *(Contracted)*
  - v) Shweli(3)-ThaPyaWa, 250 miles *(Proposed)*





Source: ADB; World Bank

… Whilst on the other hand, distributed power will likely have a key role to play

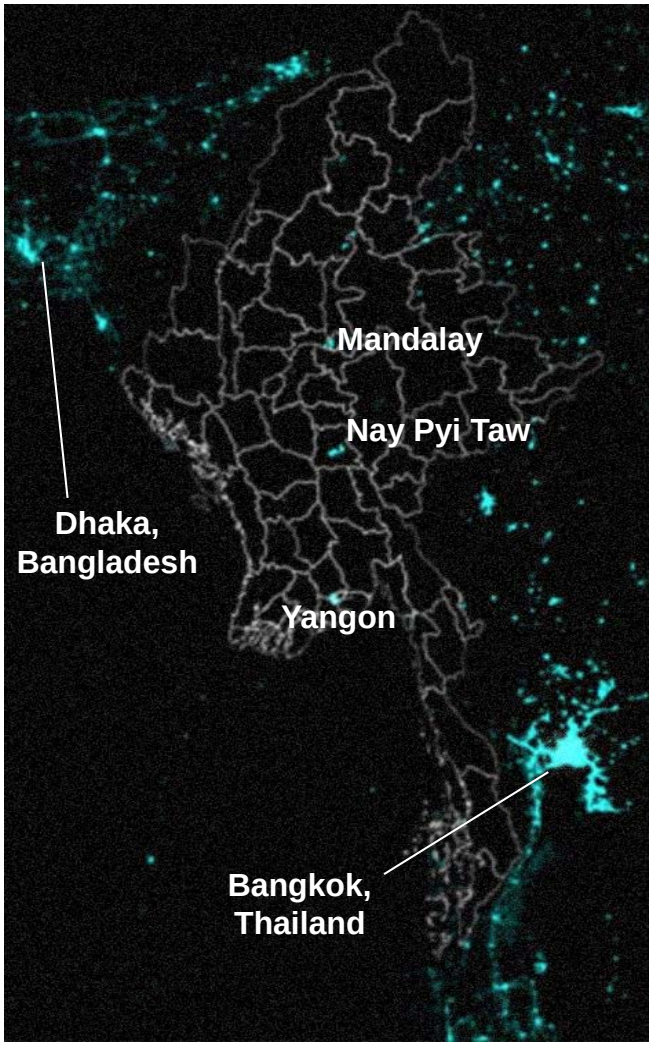
Context

- Off-grid forms of distributed generation, particularly renewables, have significant potential in markets with low levels of electrification and/or small-scale generation in remote areas.
- Conventional grid access is challenging or not economically viable given that nearly 66% of Myanmar's 53 million population lives rurally.
- Stated government targets to provide universal access to electricity by 2030, supported by a $700 million World Bank loan. Similar financing initiatives have also been used in Cambodia.

Recent developments

- World Bank loan of $700m in 2015 to support electrification programs.
- Ministry of Livestock, Fisheries and Rural Development (MLFRD) has plans to provide electrification to over 140,000 households by 2017.

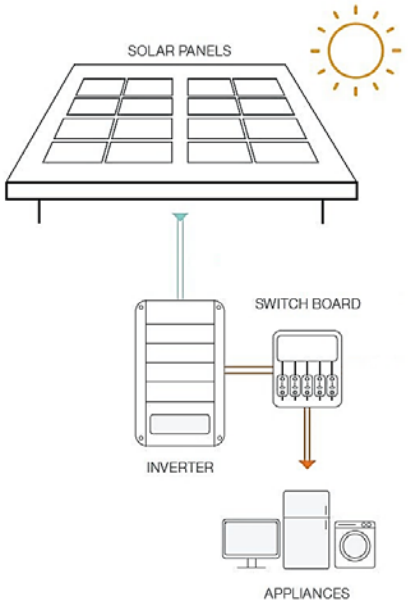
So what are the options?



Source: CSIS; IDE; TLG analysis

Solar home systems are the least-cost option for electrification in many cases

- Solar Home Systems (SHS) are becoming increasingly cost-effective for off-grid electrification, and meeting unserved demand.
- SHS is also highly versatile, particularly in rural settings with dispersed households, and where conventional electrification through grid extension is not viable.
- Brighterlite Norway AS signed an MOU in March 2016 to provide up to 3 million solar home systems in Myanmar by 2020.
- SHS programs are also receiving significant financial assistance from international aid organisations in helping countries such as the Philippines to reach its electrification targets:
    - TLG is engaging in the with Philippines Department of Energy and the World Bank in a large-scale ‘PV Mainstreaming’ program
    - 415,000 households targeted, with an initial phase of 40,500
    - Stimulating growth and competitive activity in the supply chain is key



Thank You

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Despite significant interest in coal-fired projects, it has translated into a lack of committed projects with many apparently stalled at the MOU stage

Project Name	Capacity	Fuel	Investors	Project status
Bukit Asam 'Minemouth'	600 MW	Coal	Bukit Asam	Announced
Dawei Coal Plant	4,000 MW	Coal	Italian-Thai Development PCL	Abandoned
Kalewa Unit 1	2 x 135 MW	Coal	ISDN Holdings and Tun Thwin Mining	MOU
Kengtung	660 MW	Coal	Lumpoondum Company	Pre-permit development
Kungyan Gone Stage I	300 MW	Coal	Kaung Myat Thaw Myae	MOU
Kungyan Gone Stage II	990 MW	Coal	Kaung Myat Thaw Myae	MOU
Kungyan Gone Stage III	1,980 MW	Coal	Kaung Myat Thaw Myae	MOU
Kyaukphyu Unit 2	2 x 660 MW	Coal	MCM Energy, Daewoo Company	Announced
Kyauktan	500 MW	Coal	Powergen (India)	MOU
Launglon	500 MW	Coal	24 Hour Mining and Industry, CWAVE Global	MOU
Mai Khot	405 MW	Coal	Italian-Thai Development Public Company	Abandoned
Mandalay	500 MW	Coal	Mudajaya Group	Abandoned
Myeik	2,600 MW	Coal	Various	On hold
Nga Yoke Kaung	300 MW	Coal	A1 Group, Mitsubishi Corp	On hold
Pathein Unit 1	330 MW	Coal	Tata Power Pathein	MOU
Pathein Unit 2	330 MW	Coal	Tata Power Pathein	MOU
Tanintharyi	2,000 MW	Coal	Marubeni, Global Power Synergy Company, EGAT International	Feasibility study
Thilawa	1,280 MW	Coal	Toyo Thai Power Holdings	On hold

Source: MOEP; PFI; TLG analysis