Big Grid or Distributed Solutions – a Choice or an Option?

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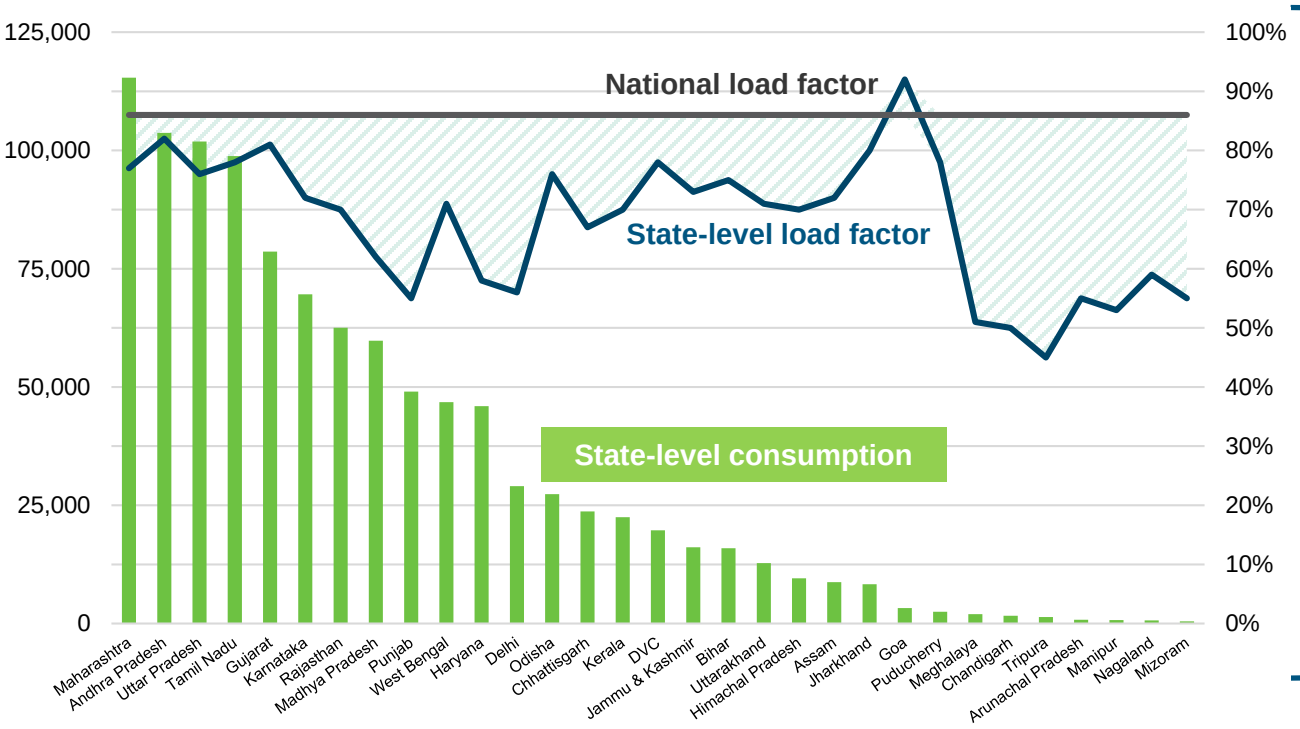
Historically, and in the present day, grids continue to yield significant benefits…

- Grids aggregate non-coincident loads, which exist due to sectoral end-use patterns, geographic scale, etc.
- This allows overall capacity requirements to be lower, whilst providing sufficient economies of scale for the efficient thermal plant to be built, and also allowing reserves and ancillary services to be shared.
- Supra-national grids, such as in Europe, are facilitating 'market coupling' and further improving the efficiency of markets and plant build-out.

State-level and national demand load factor in India (2014-2015)



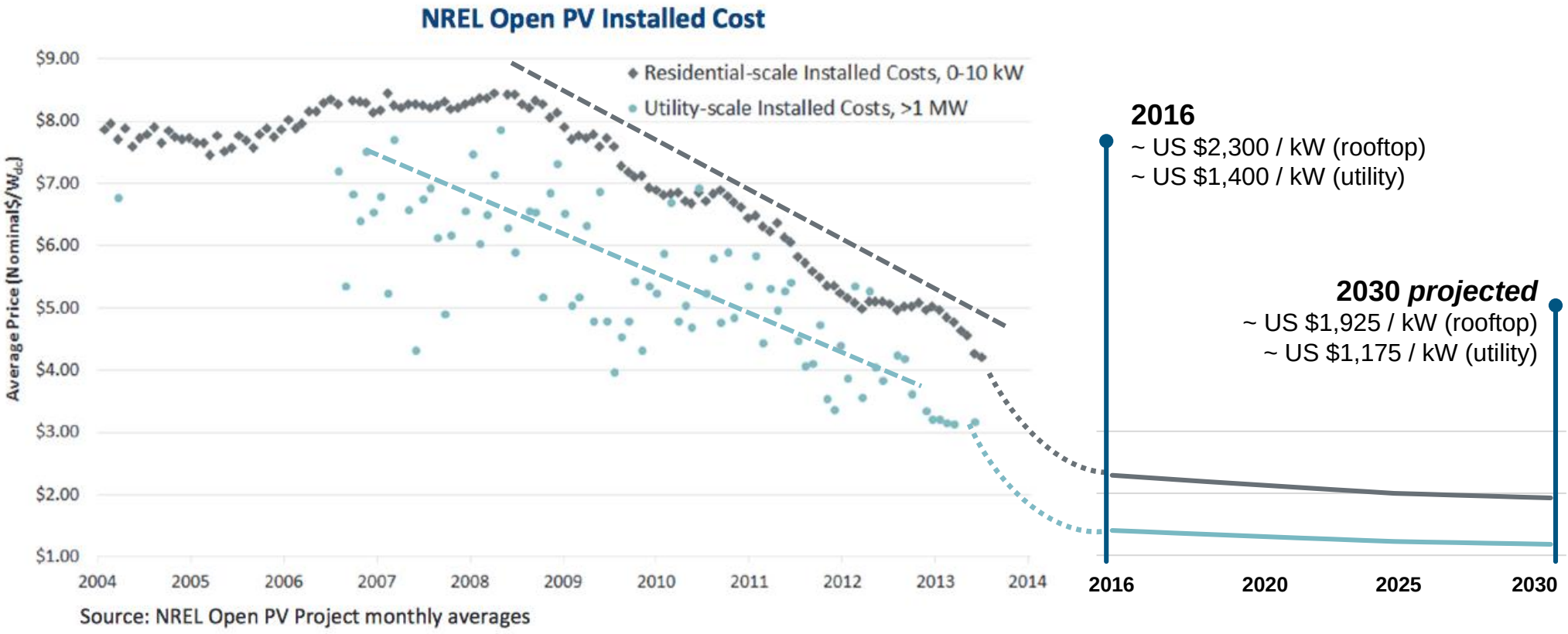
Grid benefits: an Indian example

- Particularly large regional variations in demand, due to:
  - Geographic coverage (time, weather)
  - Concentrations of industry
  - Economic inequality
- On a weighted basis, the load factor of India's 29 states is 73%, yet rises to 86% at the national level due to the combinatorial effect of non-coincident demand profiles.
- Particularly beneficial in India which operates a centrally-balanced system.

Source: Central Electricity Authority

But, falling solar costs have been a predominant theme over the past 10 years

- 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

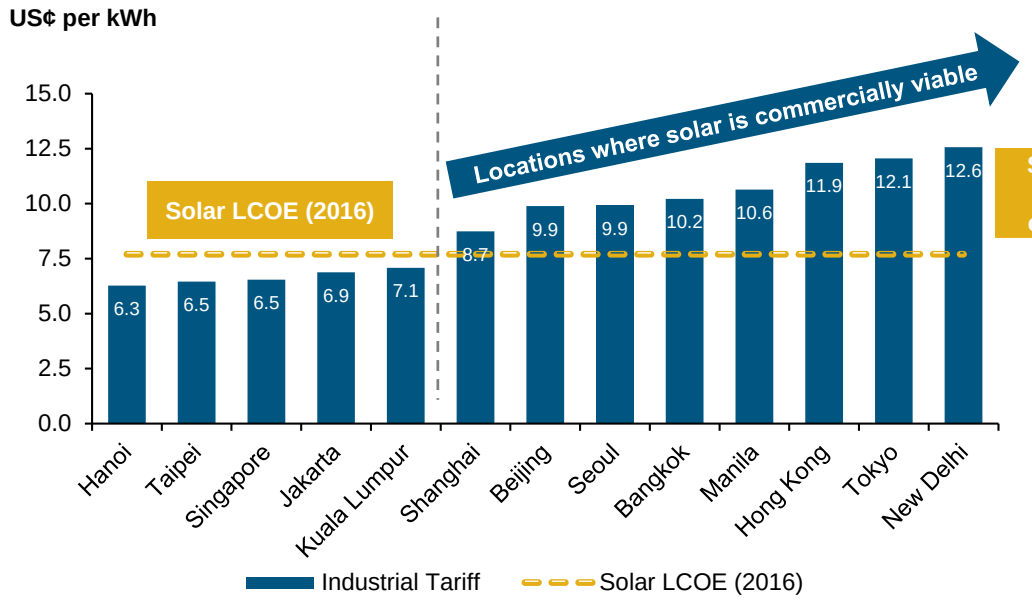


Source: NREL

In addition to Australia, and parts of Europe, the US and Latin America, grid parity is now an emergent theme for solar in Asia

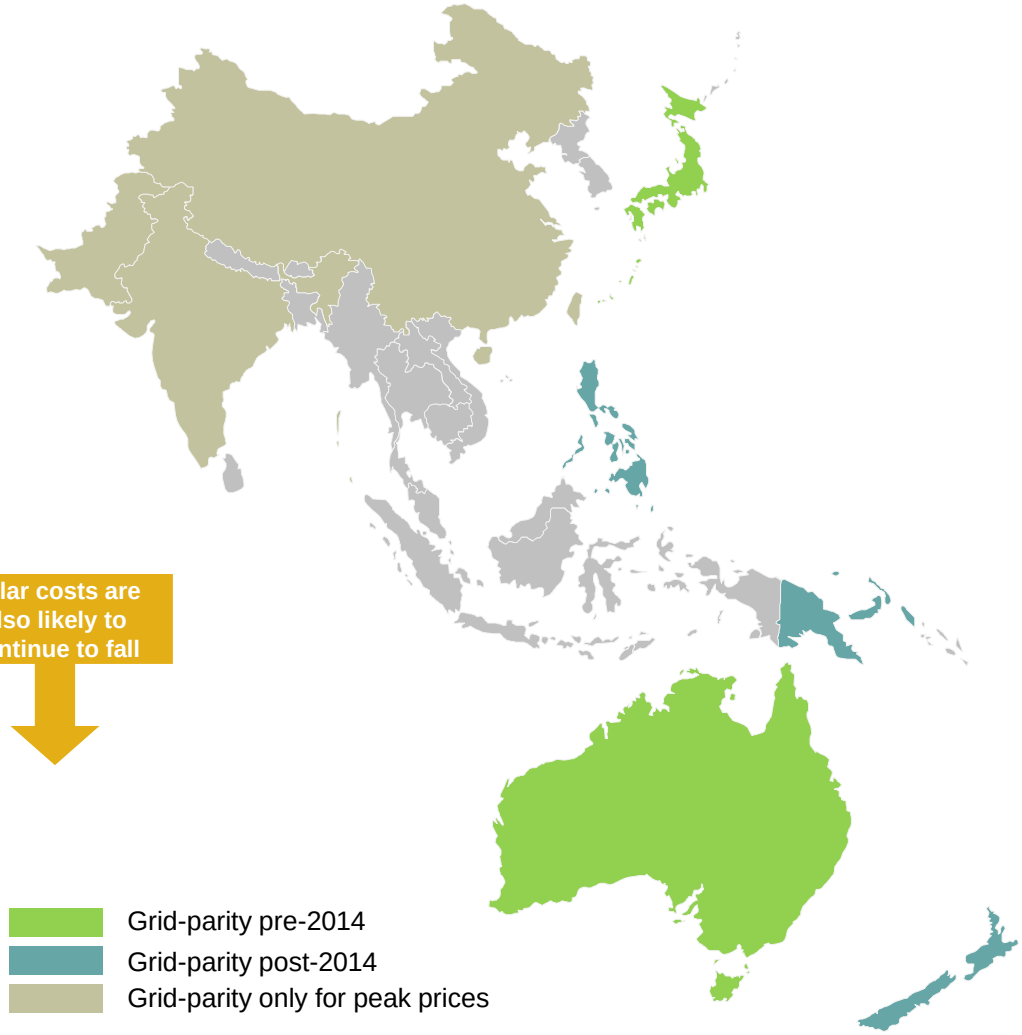
- Grid parity serves as a key indicator for adoption.
- When compared against prevailing tariffs, solar has become increasingly commercially viable in a number of Asian cities, even without the need for a FiT.
- Some estimates now see global grid parity for solar arriving by 2020.

Selected Industrial Tariff Benchmarks across Asia as of May 2016 (excl. VAT)



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

State of grid parity of solar across Asia and Australasia



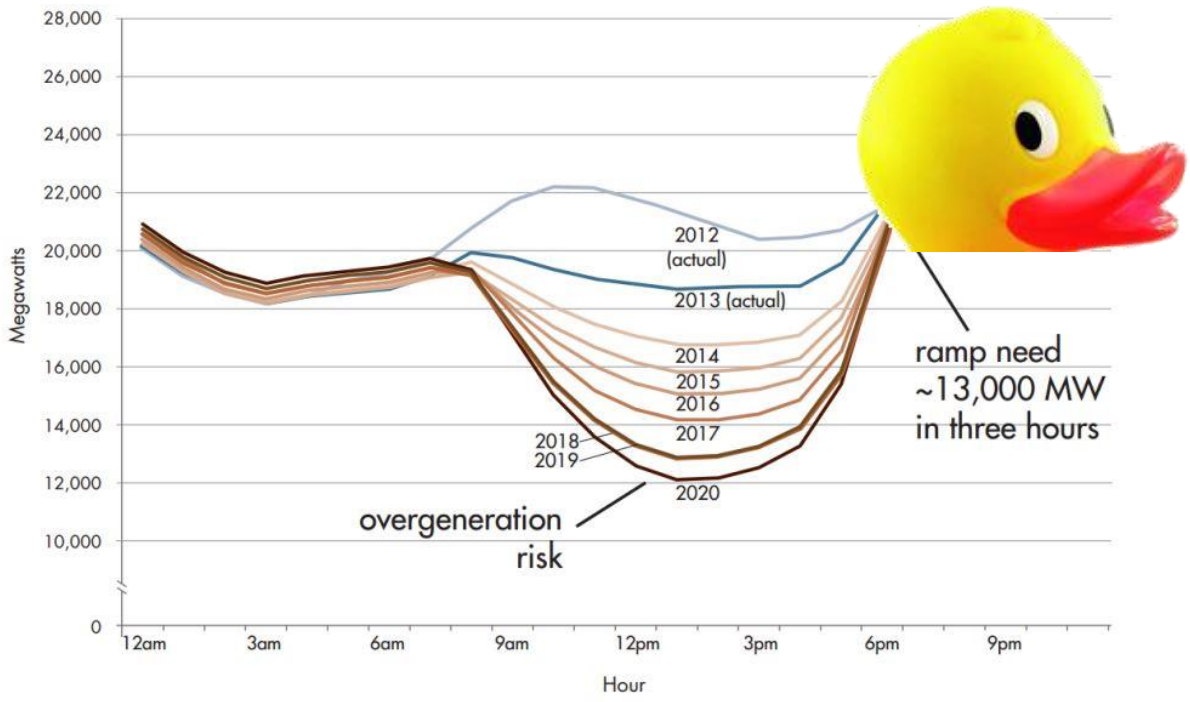
Source: Adapted from Deutsche Bank (2015)

To what extent can the grid *co-exist* with renewables and distributed generation?

In countries that ‘pioneered’ renewables, the status quo of the grid is now increasingly being challenged

- Traditional investment cycles in conventional, grid-based generation were moderated by fundamentals and market signals.
- However this ‘natural braking’ as largely been absent from policy signals, such as FiTs, that have spurred renewables growth.
- In California, the now infamous ‘duck curve’ is adversely disrupting the generation mix.
- Whilst in Germany, the excessive penetration of intermittent renewables has seen the costs of intra-day re-dispatch, and spot market volatility, rise significantly

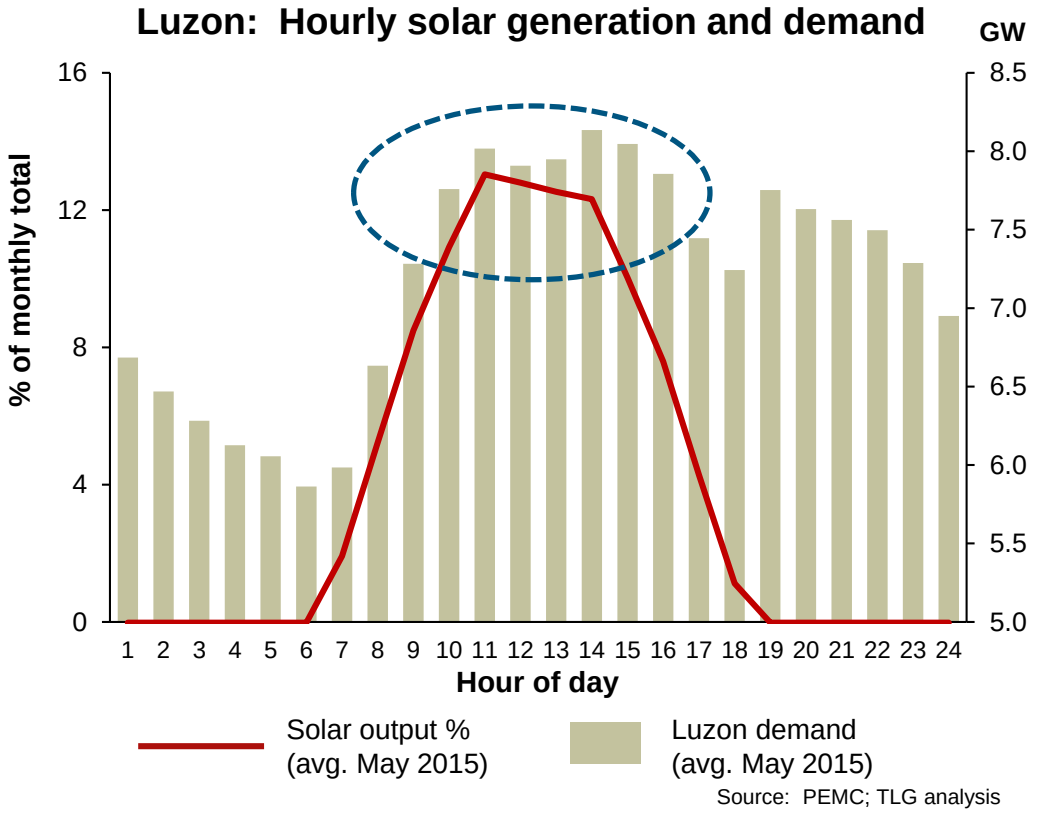
The ‘duck curve’ in California



Source: CAISO, cited by NREL

Yet if the quality and location of solar build is focal, and 'natural braking' is applied, then pitfalls can potentially be avoided

- The Philippines has operated a quota-based FiT for solar.
- The cost of FiT subsidies are passed through to all customers in a transparent manner.
- Transmission charges largely remain fixed for industrial customers, with only small residential customers able to avoid transmission costs.
  - And some utilities are looking at ways to manage these too
- On average, there is a strong match between average peak demand and the solar resource, particularly in Luzon where peak demand (and thus higher prices) fall during the middle of the day.

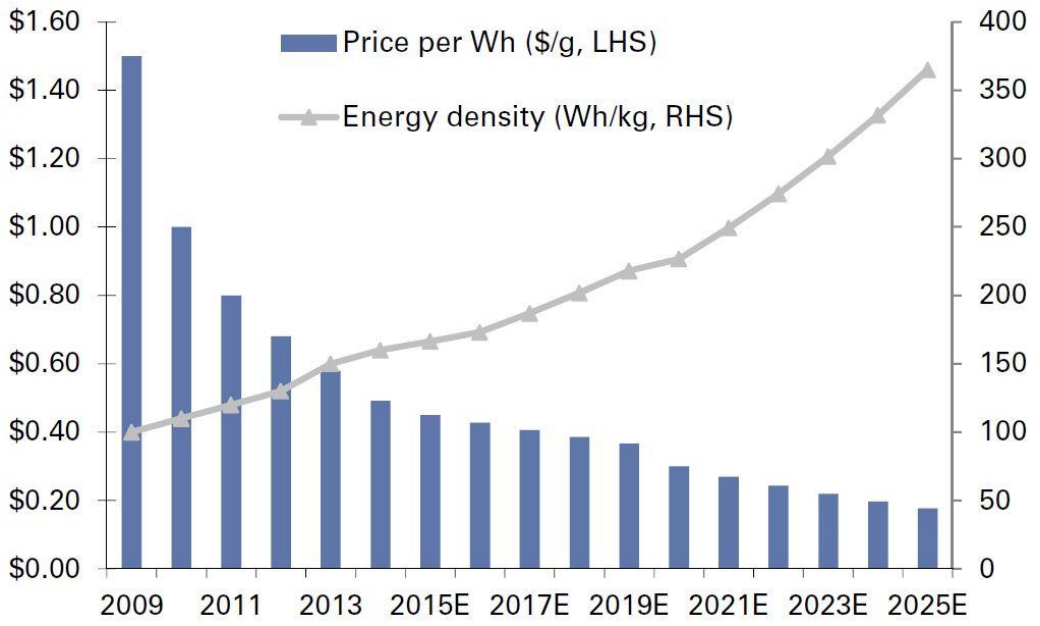


Source: PEMC; TLG analysis

Even more recently, the cost of batteries is now being driven lower by technological performance gains

- Some estimates suggest batteries may halve in cost in the next 10 years, particularly due to improvements in energy density.
- Grid-scale batteries are now becoming increasingly viable, and cost effective from a commercial standpoint.
- Looking forward, batteries may well serve to strengthen grids via:
  - Smoothing renewable intermittency
  - Shaving of peak demand
  - Back-up reserves
  - Ancillary services

Historic and forecast projections for battery cost and performance*



But this still begs the question of whether big grid has a future…

* Projections based on automotive Li-ion batteries
Source: Goldman Sachs Global Investment Research

Disruption in developed markets…

- Against the backdrop of falling costs of distributed generation, Australia has become a key battleground between grid and off-grid.
- Grid disconnection now ranks as one of the biggest risks for network companies in Australia.
- The unison of ‘solar plus battery’ technologies will likely build further momentum.
- Viewed in isolation, the shift towards distributed renewables might appear to be led by a narrow band of cost-sensitive customers with behavioural tendencies towards clean energy.

In fact, the ramifications span far wider…

Source: BBC (2016)

Disruption in developed markets…

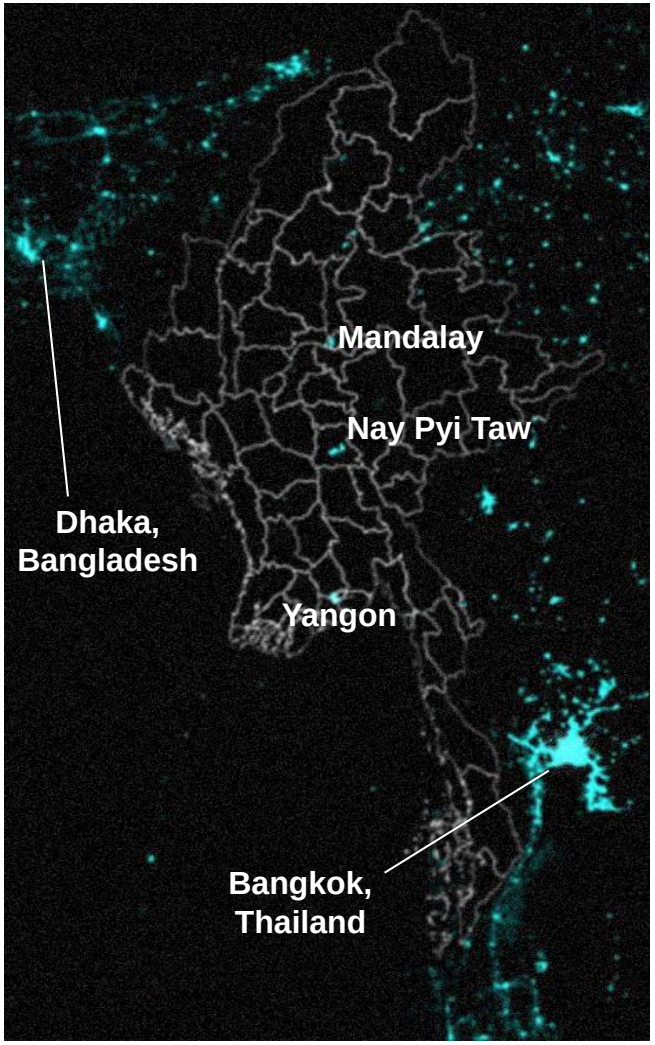
- For network companies and grid operators in their present state, the transition towards distributed generation is likely to have far reaching effects.
- Fundamentally ingrained within the business model of grid operators, is the recovery of network costs through volume-based tariffs, which provide an implicit incentive to customers to install distributed renewables, such as solar.
- Thus, as grid-based energy sales fall but grid capex continues, the recovery of network costs per kWh for the remaining grid users increases. This compounding effect provides yet further impetus for even more of a shift towards distributed generation.
- Thus how fixed costs are socialised, and how grid operators and network companies manage this socialisation becomes crucial.

Disruption in developed markets…

- Network companies, as asset owners, are therefore faced with a choice of either diminishing financial returns from a smaller market…
- … Or embracing the competition of distributed generation by focusing on value-added, innovative consumer-facing propositions that incentivise customers to stay.
- So what might the future hold?
    - Increased customisation of tariffs and pricing, by leveraging information across customer classes
    - Value-added, responsive services such as smart grid integration
    - Structural changes towards a more fixed-tariff components… which will invariably face policy and regulatory hurdles
- Nevertheless it is still difficult to see a scenario without no grid, and competition will be limited to a point…
- There will always be customers that ascribe a value to security of supply and reliability
- Grids have intrinsic benefits that distributed generation cannot mimic.

So given what we know, is a grid fundamental?

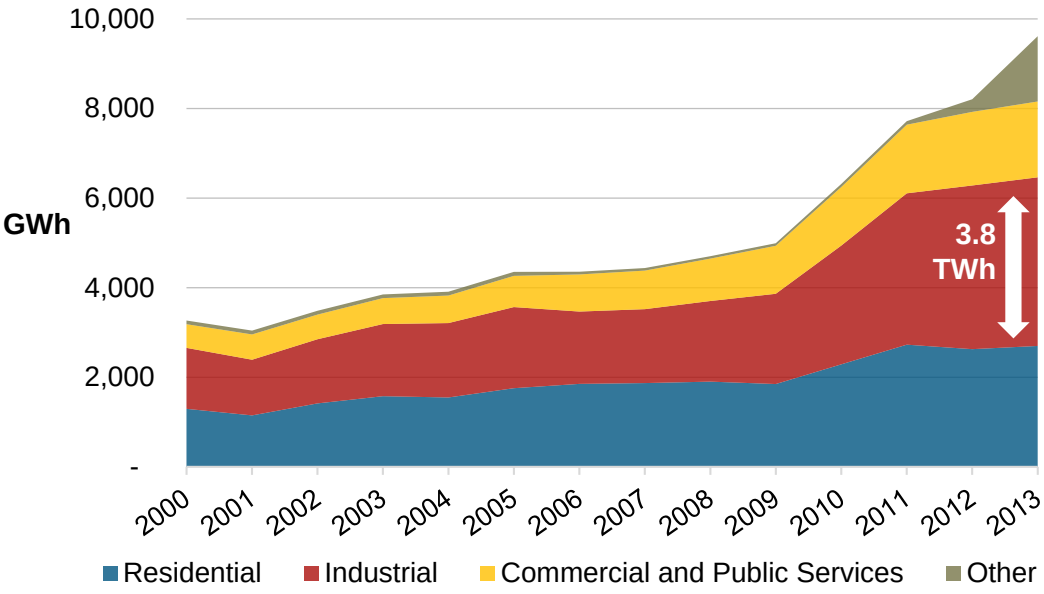
Distributed generation is **shaping** emerging markets…



Source: IDE;

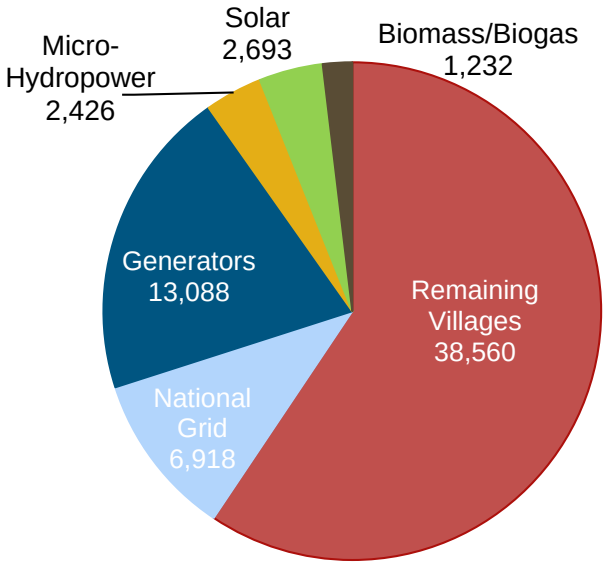
Myanmar's power sector is in its nascent stages, with demand characterised by two markedly different stories…

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.

… But substantial latent demand in rural areas



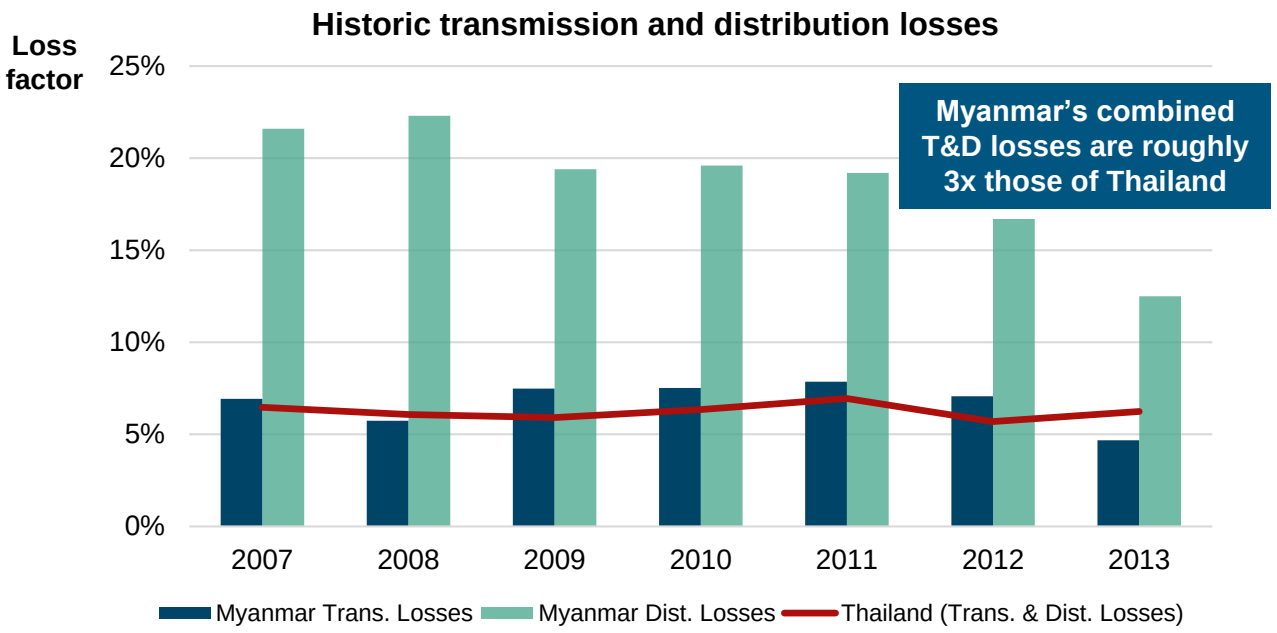
Electrification status of Myanmar's 64,917 villages *(2015)*

- Two-thirds of Myanmar's population of 53 million live rurally.
- Electrification stands at around 32% of households nationally, but 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

… With fundamental decisions being taken regarding the role of the grid

- Myanmar existing grid suffers from chronic transmission losses which are both expensive and undermine the grid's ability to support further capacity additions.
- Five core 500 kV transmission projects, spread over 800 miles, are proposed which will largely focus on strengthening the corridor between Yangon-Mandalay, and to the hydro assets in the North.
- But such costs will inherently be amortised over long periods of time.

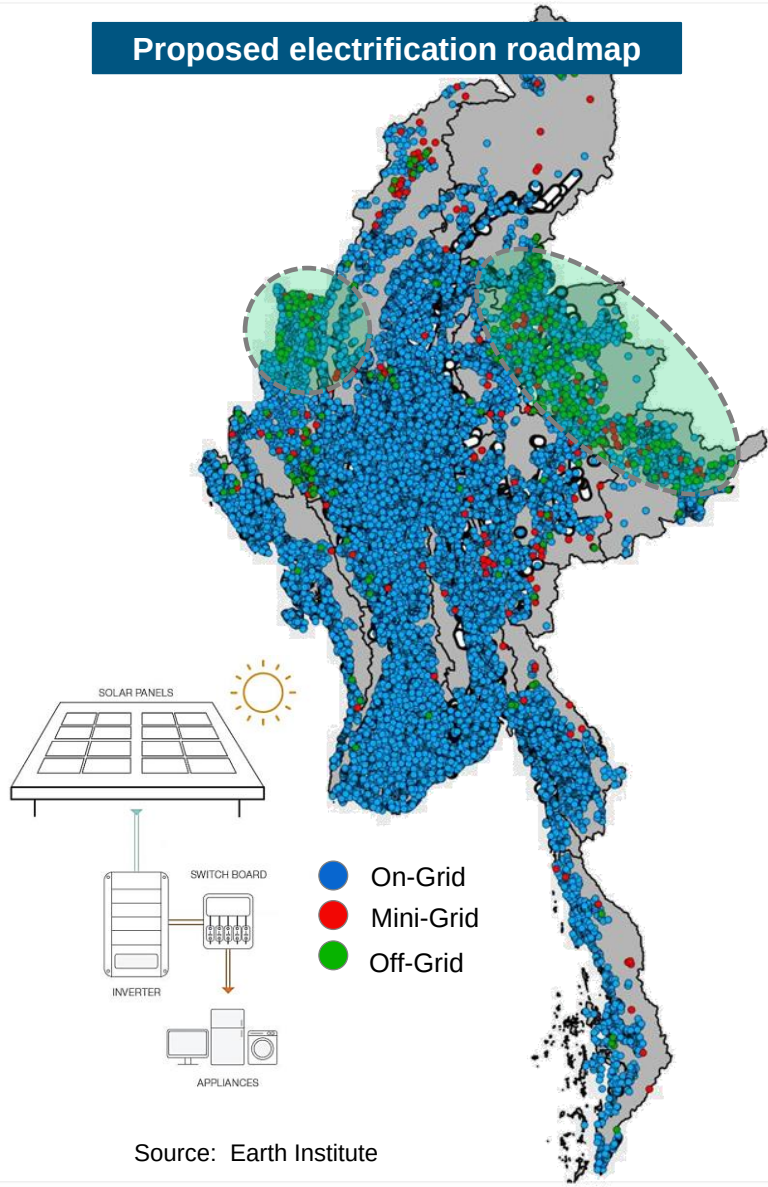


Source: ADB; World Bank

But on a ‘least cost’ path, distributed solutions such as SHS are increasingly a cheaper way to electrify unconnected regions

- Conventional grid access is challenging or not economically viable given that nearly two-thirds of Myanmar’s 53 million population lives rurally.
- Rather than grid extensions, off-grid distributed generation, have significant potential in markets with low levels of electrification and/or small-scale generation in remote, rural areas.
- Myanmar’s government targets are to provide universal access to electricity by 2030, supported by a $700 million World Bank loan.
- Ministry of Livestock, Fisheries and Rural Development (MLFRD) has plans to provide electrification to over 140,000 households by 2017.
- Whilst mini-grids have a role where rural households are clustered, SHS programs are highly versatile for dispersed households, and are now receiving significant financial assistance from international aid organisations in helping countries (including the Philippines) to reach electrification targets.
- Brighterlite Norway AS signed an MOU in March 2016 to provide up to 3 million Solar Home Systems (SHS) in Myanmar by 2020.

Proposed electrification roadmap



Source: Earth Institute

Even so, the significant cost of a - largely new - grid will be amortised over many years

- The cost of grid investment is particularly difficult to ascertain, yet it is not unusual for the cost of 500 kV transmission lines to range between US $2 million to US $2.5 million per mile. Circuit-breakers, substations, and maintenance and add yet further cost.
- Grids last a long time (50+ years!) and costs are amortised over many years and many customers, raising the question of how future-proof such fundamental decisions are – particularly in cost sensitive economies such as Myanmar.
- On the other hand, decisions to install solar or a battery have significantly shorter payback periods but result from individual choice.
- Increasingly rapid changes in distributed generation technologies, and inherently shorter payback periods provide options to install now and replace / upgrade later with newer solutions - potentially resulting in a better outcome.

Source: Black & Veatch; Caiso

Given these varying contexts, is a debate on the role of the grid even necessary? Is it a case of either/or?... or should we be looking to ensure we have the right frameworks in place good decisions?

Correctly pricing grid tariffs, thus providing the right economic signal to the consumer, will allow the right balance between grid and off-grid to be struck

- As grid operators adapt to become more competitive and differentiate the services they provide to customers, tariffs must in turn correctly reflect the costs of these services.
- Some examples:
  - A grid providing a **backup service** is essentially providing insurance, and should thus reflect a fixed cost for a defined size (MW) and duration (hours) of backup.
  - Providing an **ancillary service** benefit should be priced as such, and bundled into energy charges.
- Looking further ahead, smart grids will inherently offer more control (and thus value) to an increasing number of customers, yet those who choose not to pay the appropriate cost of this service should not receive it.
- Phone bills offer a useful analogue:

  If you don't pay your phone bill, the phone company cuts you off…

  … **HOWEVER** - users can opt to pay for data but not voice, or voice but not texts, and so on.

It is crucial to that network companies think about what grid services should be bundled, and for which everyone must pay, and what services should be optional and for which people choose to pay

Ultimately, some exceptions are likely to remain…

- Grids still possess intrinsic and inimitable value, such as backbone transmission services that link major generation and load centres, and the costs of which must continue to be borne by all users unless they disconnect entirely.
- Thus the main threat of off-grid appears to be to distribution networks, and not transmission networks.
- Undoubtedly, difficult choices (and regulatory hurdles), lie ahead:
  - Those with rooftop solar who wish to export power back to the grid, should pay for the infrastructure to do this - even if "their" solar is recycled back to them. Batteries are not free, so using distribution networks to do the recycling should not be free either!
  - Those with solar plus batteries who do not want to pay for the grid, should be disconnected. If solar plus batteries (without a grid connection) turns out to be cheaper and as secure as mainstream grid power, then the grid will have to evolve faster - and potentially downsize.
- Ultimately, the right economic decision is the one at the MARGINAL cost, and not the average cost. To ensure consumers make the right decisions (most likely staying on the grid) they should bear the marginal cost…

… Which may of course mean that distribution networks stop investing.

Thank you

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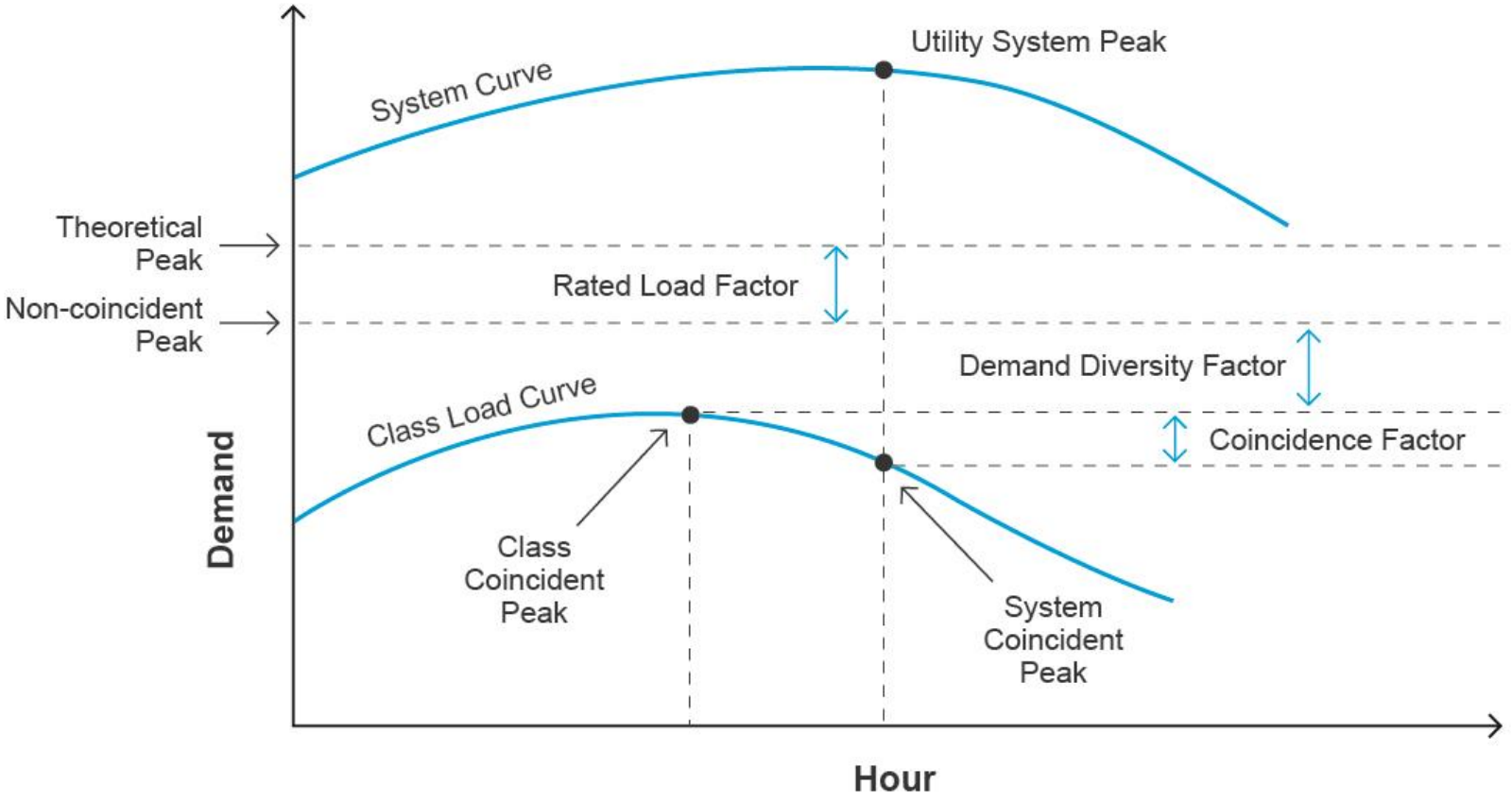
Non-coincident demand



Source: Jacobs (1993), cited by Navigant