



Grid Integration of Renewable Energy in India

Flexing India's Energy System through Market Mechanisms

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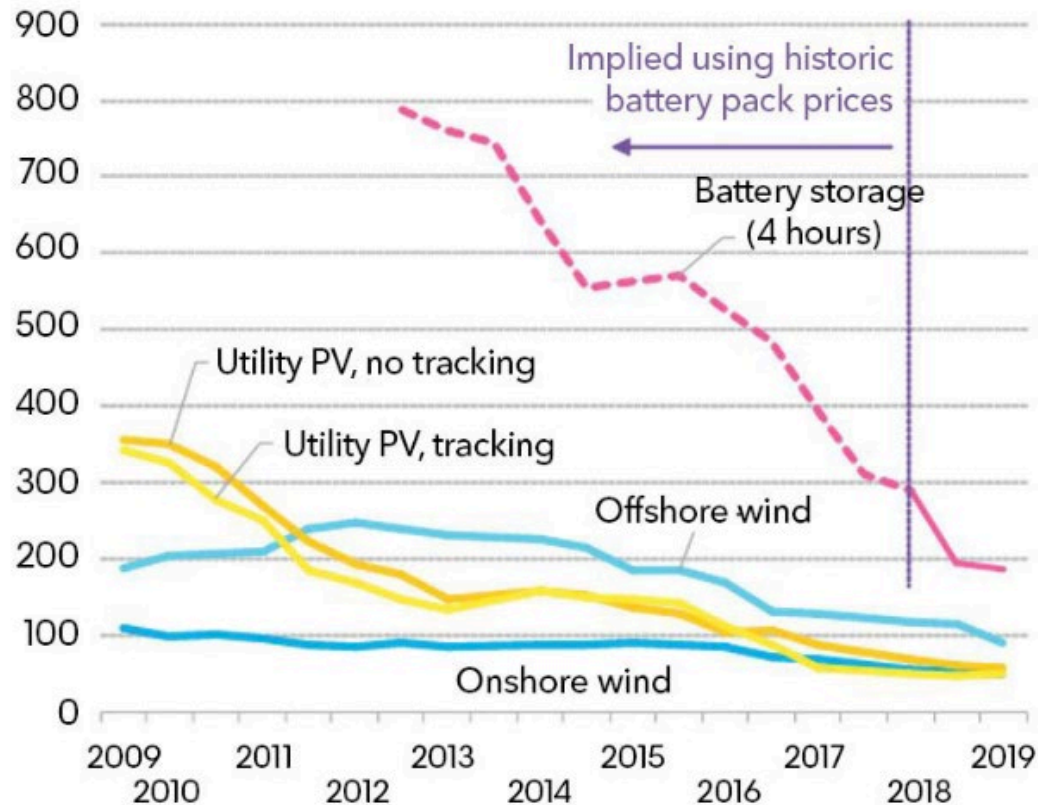
Agenda

- A global energy system transformation is well underway: Renewable energy (RE) and storage cost deflation is entrenched and ongoing
- Investment in thermal power generation globally is structurally challenged, stranded assets are rising and bank capital exiting.
- India's CEA has an ambitious roadmap for 523GW of renewable energy by 2030. Such a rate of transformation will be challenging, particularly for grid balancing of variable renewable energy (VRE).
- India is best served pursuing all viable technology solutions for grid balancing: peaking gas; pumped hydro storage (PHS); utility scale & behind the meter batteries; faster ramping coal; solar thermal (CSP); DRM; Power-to-X & grid interconnectivity.
- We examine three other leading markets like California, Germany and South Australia to compare balancing tools.
- A time-of-day pricing signal is needed to incentivize peaking power.

Renewables are very deflationary

Global benchmarks - PV, wind and batteries

LCOE (\$/MWh, 2018 real)



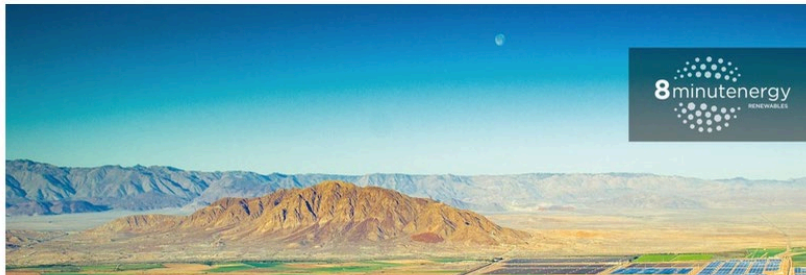
Source: BloombergNEF. Note: The global benchmark is a country weighted-average using the latest annual capacity additions. The storage LCOE is reflective of a utility-scale Li-ion battery storage system running at a daily cycle and includes charging costs assumed to be 60% of whole sale base power price in each country.

Renewable Record Lows Continue to be Set

Los Angeles seeks record setting solar power price under 2¢/kWh

The city's municipal utility is readying a 25-year power purchase agreement for 400 MWac of solar power at 1.997¢/kWh along with 200 MW / 800 MWh of energy storage at 1.3¢/kWh.

JUNE 28, 2019 JOHN WEAVER



Portugal Bags Lowest-Cost Solar Bid In The World

August 1st, 2019 by Charles W. Thurston CleanTechnica

The Portuguese energy secretariat has secured 1.15 GW of solar development at an average cost of €20.33 (\$22.53 per MWh), representing an investment of about €800m.

One of the bids was made at €14.76/MWh (\$16.44/MWh), which was declared a new world record for low solar bidding, according to Portugal's Journal Económico. The secretariat had placed a €45/kWh ceiling on bidding.

"We made a unique model in the world because it was the first auction in the world to directly compete with fixed rates and market rates with contribution to the system. There has never been such an auction in the world, this was the first," Secretary of State for Energy João Galamba told the news agency.

The auction included 24 projects, of which 23 attracted bids and were awarded to 13 bidders. Spain's Iberdrola won 7 of the 24 licenses available, as the largest number of projects gained by one bidder. France's Akuo won 370 MW, the largest project in the auction, according to Jornal de Negocios.

Brazil A-4 auction signs 211 MW of solar for record-low price of \$0.0175 kWh

Cracking the two-cent-mark as a global standard for PV appears within sight as projects in the U.S. and Brazil have been signed below that threshold. Just two years ago the industry celebrated sub-three-cent bids in the MENA region. Prices have come down so quickly, however, the new records are another third cheaper.

JULY 1, 2019 MARIAN WILLUHN PV-Magazine



Brazil's most recent A-4 renewables auction saw 211 MW of PV capacity signed at \$0.0175/kWh – a new world record.

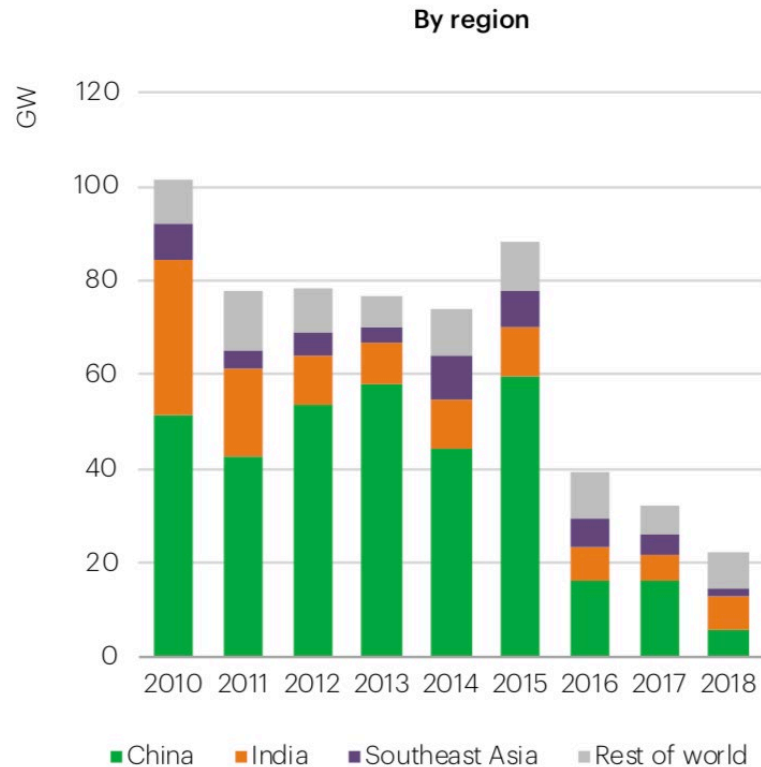
Brazil's Agencia Nacional de Energia Eléctrica (Aneel) announced results featuring a remarkable price for solar. The tender contracted 401.6 MW of renewable energy generation capacity, with solar taking a lion's share of 211 MW, according to Aneel.

The 211MW amounted to five projects with a 30 MW generation capacity each plus a 61MW facility. The smaller projects prompted one bid of BRL64.99/MWh (\$16.88/MWh) and the average price fell to BRL67.48/MWh (\$17.52/MWh) breaking the magic two-cents per kilowatt-hour sound barrier.

Global energy systems are transitioning

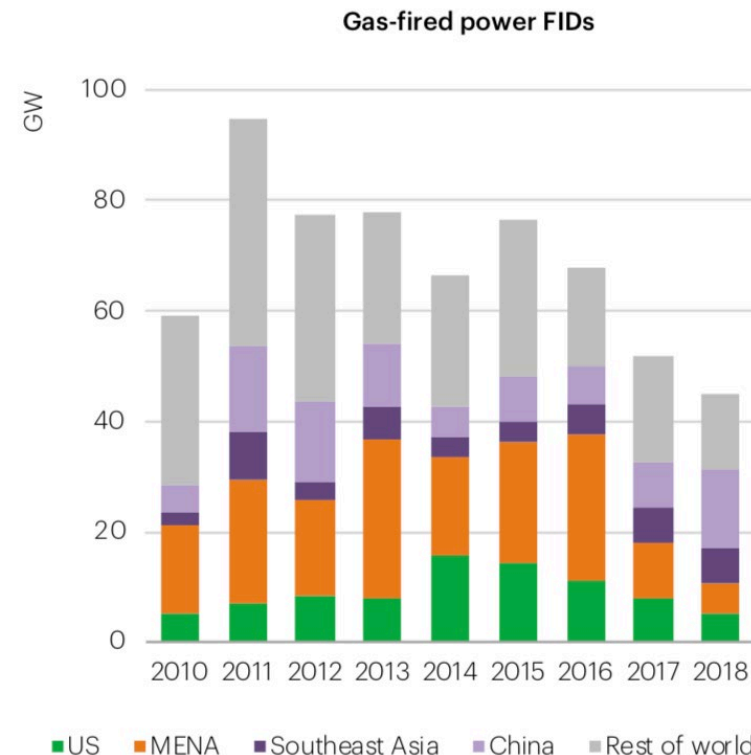
IEA's World Energy Investment 2019

Coal-fired power generation capacity subject to an FID



Note: GW = gigawatt.

Source: IEA analysis with calculations based on McCoy Power Reports (2019)



Source: IEA analysis with calculations based on McCoy Power Reports (2019) and IEA (2019)

109 global financial institutions are exiting (thermal) coal

A new announcement on average every week in 2019

- **CommBank** of Australia & **Sumitomo** of Japan announced new policies in Aug 2019
- **Suncorp** of Australia and **Chubb** of the U.S., **KfW** Germany & **EIB**, July 2019
- **DBS**, **UOB** & **OCBC** of Singapore & **MUFG** of Japan, **Hannover Re** of Germany & **UBS** of Switzerland ceased offering coal power plant financing in April/May 2019.
- **MAPFRE** of Spain, **UNIQA** of Austria and **QBE** of Australia exited thermal coal insurance March 2019, and **SDIC**, the first in China.
- **Varma**, Finland and **VIG** of Austria exit coal insurance/divest coal holdings Jan/Feb 2019
- **Citi** US ceased offering coal-fired power plant project finance globally Dec 2018
- **Generali** of Italy coal exit Nov 2018
 - follows **SCOR** France, **Munich RE** of Germany, **Swiss Re** Zurich, all in 2018
- **Standard Chartered UK** exiting coal power plant financing globally Sept 2018
- **Marubeni Corp Japan** exiting coal fired power plant development Sept 2018
- **Dia-Ichi Life then Nippon Life of** Japan ceased overseas coal insurance May & July 2018
- **Sumitomo Mitsui Trust Bank** Japan introduces global coal exclusion July 2018
- **HSBC** stops most coal power lending (except 3 emerging market countries) April 2018
- **Wells Fargo** announces a US\$200bn RE target for 2030 in April 2018
- **BBVA Spain** exits coal/US\$100bn RE in Feb 2018
- **APRA's** Geoff Summerhayes Nov 2017, **ASIC's** John Price June 2018 RBA's Guy Debelle in March 2019 all talked about systemic financial risks of climate change

The Largest Renewables Tender Ever



China Approves 22.8 Gigawatts Of Solar PV For 2019 Subsidies

July 15th, 2019 by Joshua S Hill CleanTechnica

Last week, China's National Energy Administration announced the results of its first national solar auction for Feed-in Tariff (FiT)-approved projects, in which it awarded 22.78 GW across 3,921 projects, all of which must be completed and grid-connected by the end of the year.

As has already been covered extensively, China's solar industry had a slow start to 2019, installing only 5.2 GW due to a lack of certainty about the future of the government's solar policy. However, with its Feed-in Tariff policy for 2019 finally announced in late-April, and 21 GW of grid-parity wind and solar projects announced in late May, the second half of 2019 is expected to outshine its sluggish start. In July, **China's National Renewable Energy Centre** (CNREC) announced that a total of 7.61 GW of new solar capacity was installed between January and May 2019, a decrease of 44% year-over-year.

Unsurprisingly, this meant that Chinese renewable energy investment plummeted 39% over the first half of the year, dragging global renewable energy investment down 14%.

However, the second half of the year looks like it will see an explosion of solar PV activity, with China's National Energy Administration announcing last week approval for 3,921 projects worth 22.78 GW to receive FiT. According to the **Asia Europe Clean Energy (Solar) Advisory** (AECEA) group, a total of 4,338 projects worth 24.55 GW were submitted for approval, but 417 projects worth 1.77 GW were not approved.

At an average tariff of
Rmb33/kWh
(US\$48/MWh),
delivery by 2020,
down 35% the price
of 2018 FiT for projects
completed 2019.

China Aims to Dominate the next Industrial Revolution, Globally



How China will rule the next industrial revolution

Foreign Policy, AFR, 17 May 2019

A fight between the [United States and China](#) is brewing over [5G](#) and the question of who can be trusted to control the world's wireless infrastructure. But scant attention is being paid to an issue of arguably greater importance to the future of the world's economy and security: China's control of the raw materials necessary to the digital economy.

No new phone, tablet, car, or satellite transferring your data at lightning speed can be made without certain minerals and metals that are buried in a surprisingly small number of countries, and for which few commonly found substitutes are available.



China's pursuit of the raw materials essential to the digital economy has far-reaching global implications.

Operating in niche markets with limited transparency and often in politically unstable countries, Chinese firms have locked up supplies of these minerals and metals with a combination of state-directed investment and state-backed capital, making long-term strategic plays, sometimes at a loss. This analysis reveals how rapidly and effectively China has executed its national ambitions, with far-reaching implications for the rest of the world.

China's 13th Five-Year Plan declared [2016 to 2020 a "decisive battle period"](#) for the nonferrous metal industry. Its hallmark initiative, "Made in China 2025", aims to build strategic industries in national defence, science and technology.

China aims to be the world leader in zero emissions industries of the future, including vertical integration up to the raw materials needed. China chooses not to play by western stock market rules.

China Electricity

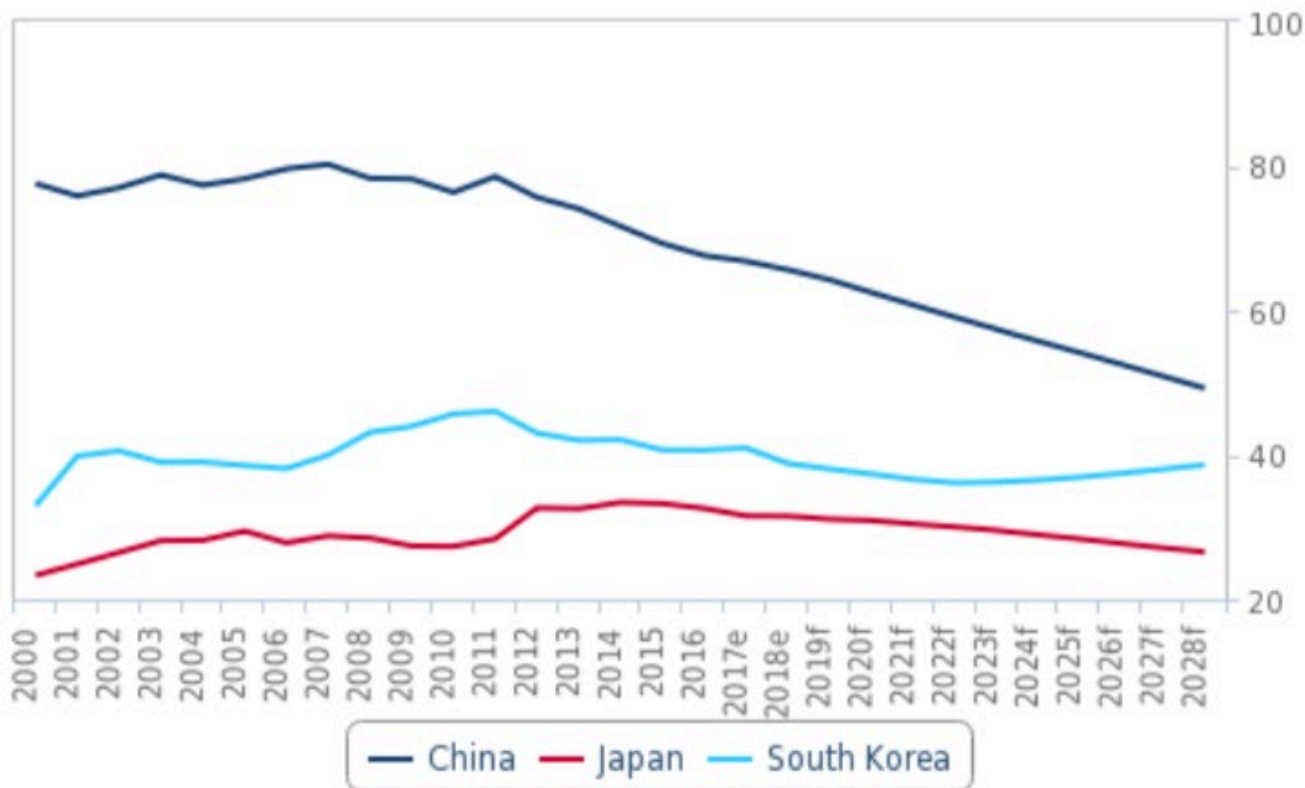


Pressure On Coal Power In China, Japan & South Korea Increasing

Coal % Of Total Power Generation By Market

**China electricity
Jan-June 2019:**
IP +6.0% yoy
Total +3.3%
Thermal +0.2%
Hydro +11.8%
Nuclear +23.1%
Wind +6.6%
Solar +11.2%

**June 2019 China
had 750 GW of RE
including:**
354 GW hydro
193 GW wind
186 GW solar



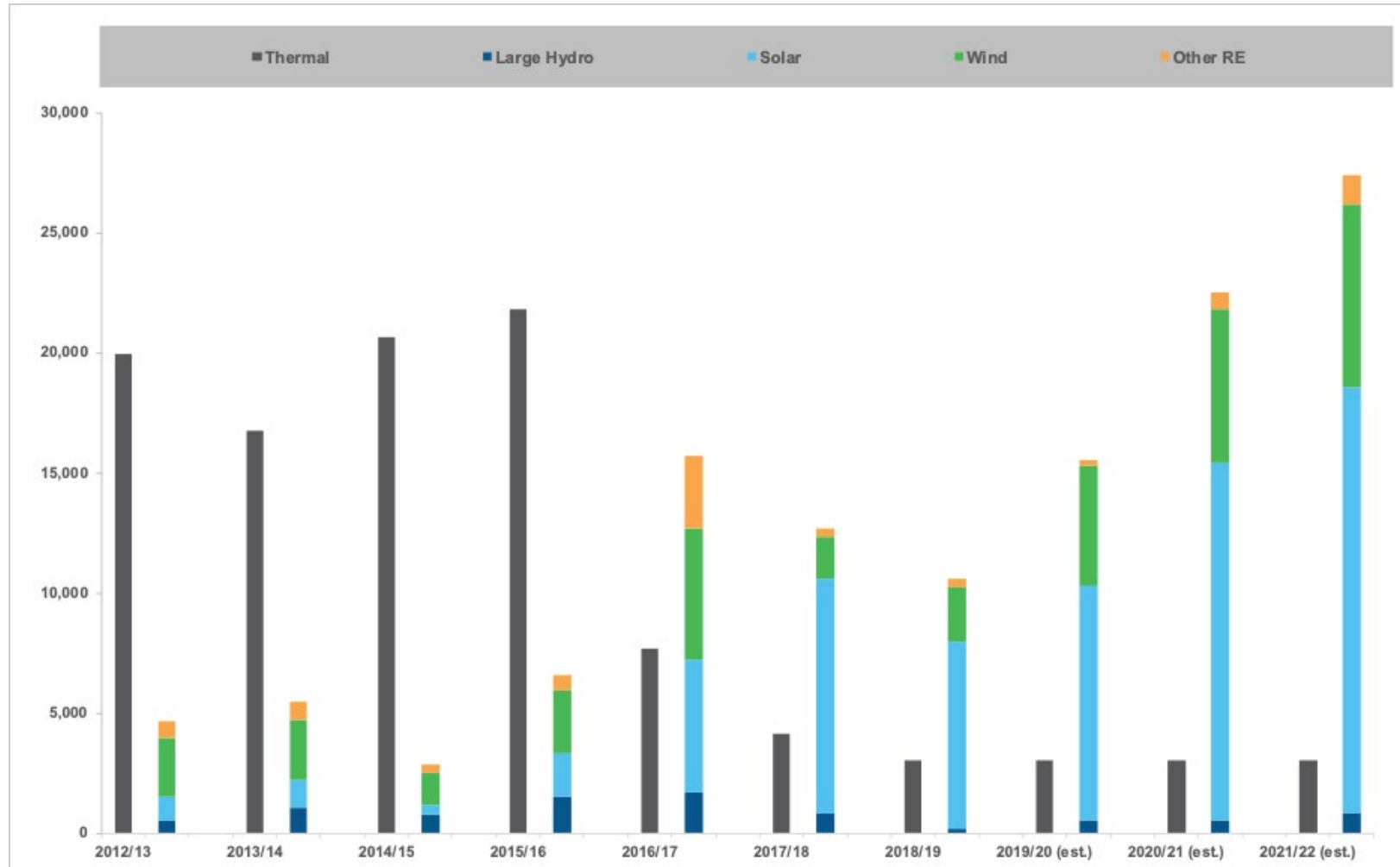
e/f = Fitch Solutions estimate/forecast. Source: EIA, Fitch Solutions



Indian VRE was 9.2% of 2018/19 Generation

	---- Capacity ----		-- Generation --		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW yoy
Coal-fired	200.7	56.3%	1,022.3	74.3%	58.7%	3.5
Gas-fired	24.9	7.0%	49.8	3.6%	22.8%	0.0
Diesel-fired	0.6	0.2%	0.1	0.0%	1.9%	-0.2
Large Hydro	45.4	12.7%	134.9	9.8%	34.0%	0.1
Nuclear	6.8	1.9%	37.8	2.7%	63.7%	0.0
Renewables	77.8	21.8%	126.8	9.2%	19.7%	8.6
Bhutan (Import)	n.a	n.a	4.4	0.3%	n.a.	
Total	356.3	100%	1,376.1			12.1
Capitve power	51.4					
Total	407.7	114.4%				

Indian Thermal Power Capacity Net Additions down 80% in three years



Karnataka #1 RE State in India



Solar & Wind Met Over 50% Of An Indian State's Energy Demand 3 Days This Month

July 22nd, 2019 by Mridul Chadha CleanTechnica

For three consecutive days earlier this month, the state of Karnataka satisfied more than 50% of its energy demand from solar and wind energy projects.

With the advent of the monsoon season, generation from wind energy projects has surged sharply, especially in the southern region. One of the states in this region recorded a huge increase in generation from wind as well as solar power projects, which together supplied a majority of its energy consumption for a few days earlier this month. The feat was achieved by the state of Karnataka, which was the 7th largest energy consumer in India in the financial year 2018–2019, with nearly 72 billion kWh consumed.

Karnataka's Electricity Sector Transformation

India's Leading Renewable Energy State

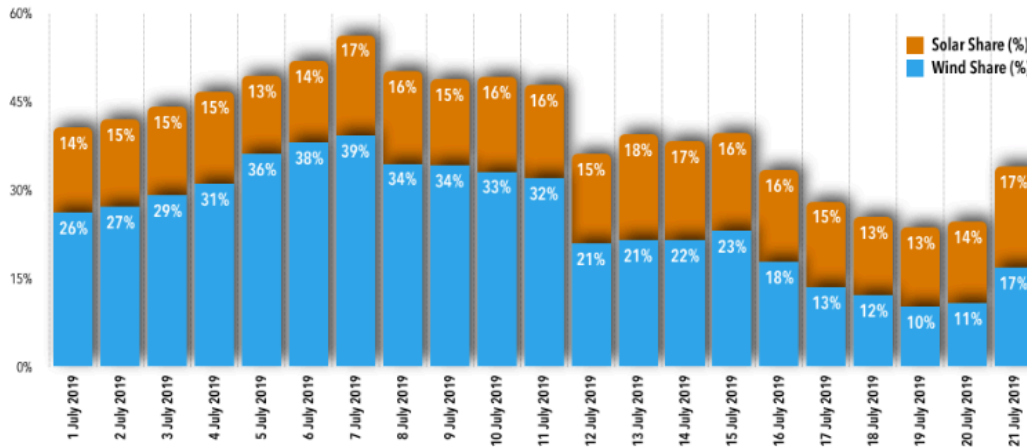


July 2018

Tim Buckley, Director of Energy Finance Studies, Australasia (tbuckley@ieefa.org) and

Kashish Shah, Research Associate (kshah@ieefa.org)

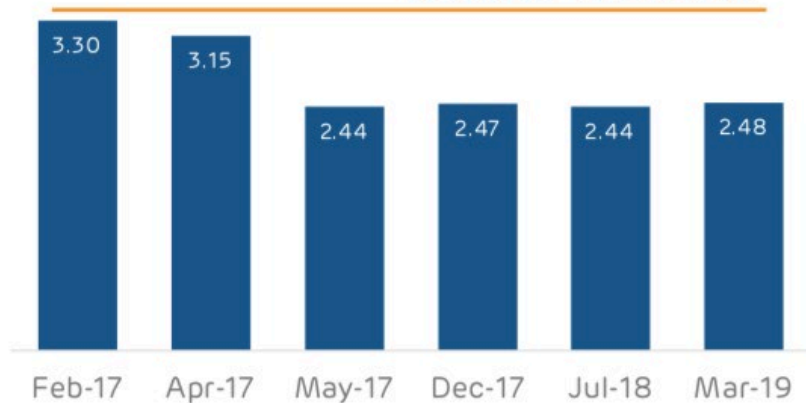
Share of solar and wind energy generation in Karnataka's total energy consumption



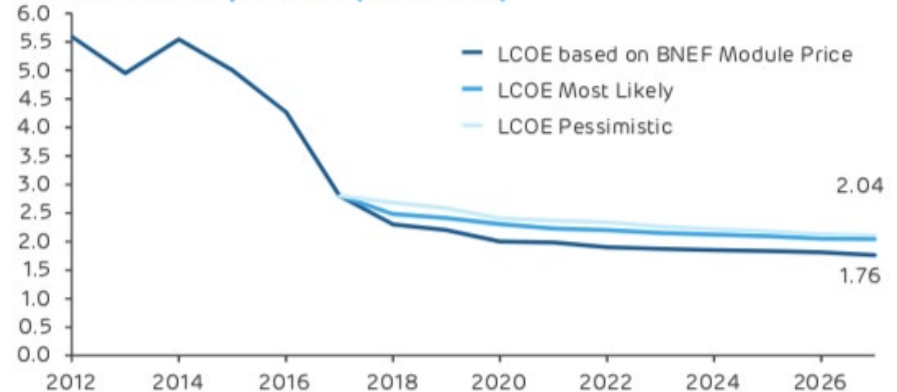
Data: Government of India • Graph: Mridul Chadha, Cleantechnica Research

Indian Renewables are the low cost solution, and deflationary thereafter

Growth Drivers – India achieves Grid Parity - Solar
CERC APPC - INR 3.50 / kwh



Solar LCOE Projections (INR / kwh)



Growth Drivers – India achieves Grid Parity - Wind
CERC APPC - INR 3.50 / kwh



SECI Tenders 1.2 GW of Solar-Wind Storage Projects with Assured Peak Power Supply

Mercom India, [Ramya Ranganath](#), Aug 2, 2019

The Solar Energy Corporation of India Limited ([SECI](#)) has issued a Request for Selection for setting up 1.2 GW of renewable projects connected with the interstate transmission system (ISTS) and with a guaranteed peak power supply (ISTS-VII).

In this tender, a project should have at least two components. One will be the energy storage system (ESS) component and the other will be the renewable energy generating component. The RE generating component can be either a solar photovoltaic (SPV) system or a wind energy system or a hybrid system of both technologies.

Projects selected under this RfS will be eligible for two-part tariffs: Peak Tariff and Off-Peak Tariff. Energy generated during the off-peak hours will be eligible for a flat tariff payment ₹2.70 (~\$0.03)/kWh while the energy generated during the peak hours will be purchased at the tariff discovered through e-reverse auction, SECI has specified. The bidders need to quote only for the peak tariff under this RfS. The applicable tariff under the PPA would comprise both peak and off-peak tariffs that will be fixed for the entire term of the PPA.

California: Renewable Energy at a Record High



- Renewables generated 34% of California's 2018 total electricity.
- In August 2018, California enacted Senate Bill 100, setting a target of 100% carbon-free electricity by 2045 (60% by 2030).
- From 2020 all new houses must have rooftop solar & 2025 for C&I.
- In 2018, PG&E launched construction of the world's two largest utility-scale battery projects to-date: a 300MW/1,200MWh and a 182.5 MW/730MWh project (both supplied by Tesla).
- June 2019 saw LADWP sign a PPA for the proposed 400MW Eland solar project at US2.0¢/kWh (zero escalator for 25 years) & 200MW/800MWh of energy storage at an additional US1.3¢/kWh.
- June 2019 saw GE close a 10 year old Californian 'baseload' gas power plant, one-third of the way through its engineering life.
- Gas peakers, batteries, CSP, DRM and grid interconnectivity.

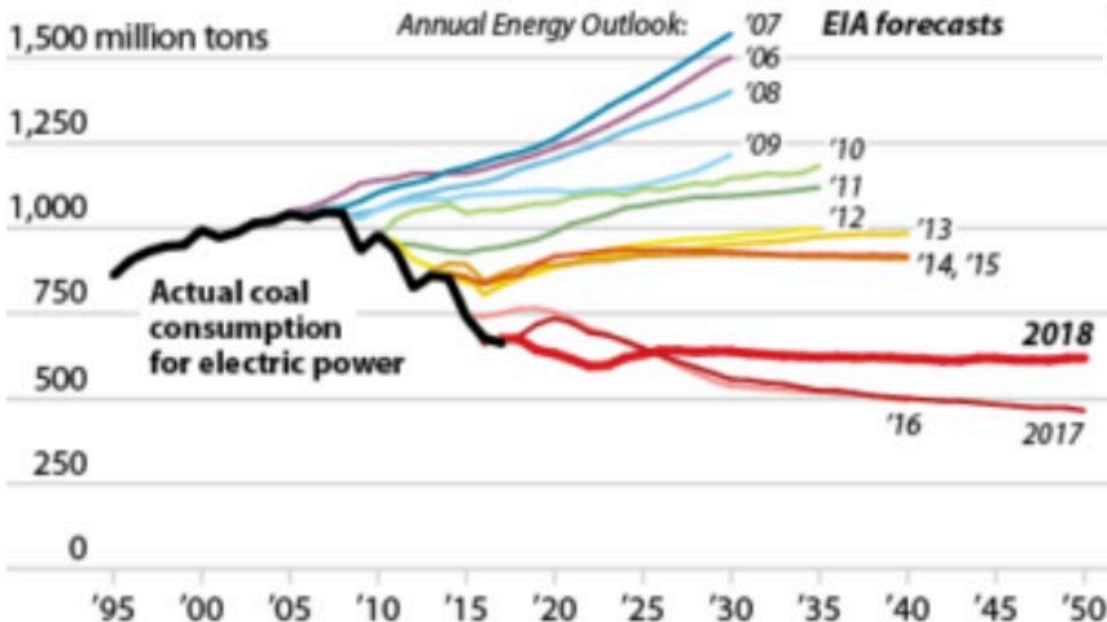


America is exiting coal



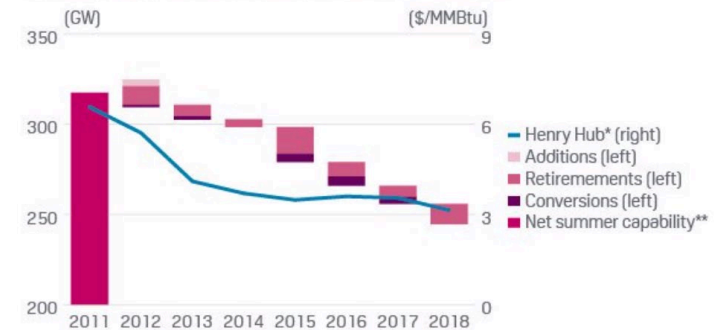
EIA Coal Consumption Forecasts, 2006-2018

Each year, the Energy Information Administration releases its Annual Energy Outlook, which includes a long-term forecast for U.S. coal consumption for electric power generation. However, the forecasts have been wildly inaccurate, even in the near term.



Source: Energy Information Administration

US COAL FLEET SHRINKS AS GAS PRICES FALL



*Three-year average with a two-year lag

**The capacity available under typical summer peak conditions

Source: S&P Global Platts Analytics

Note: Like the IEA, the EIA continues to get their forecasts entirely wrong.

Trump vowed to bring back coal.

US coal production in 2019 to-date is -9% yoy.

There will be no recovery.

Germany: Renewable Energy at a Record High



Net public electricity generation in Germany in 2019

date selection

year: 2019

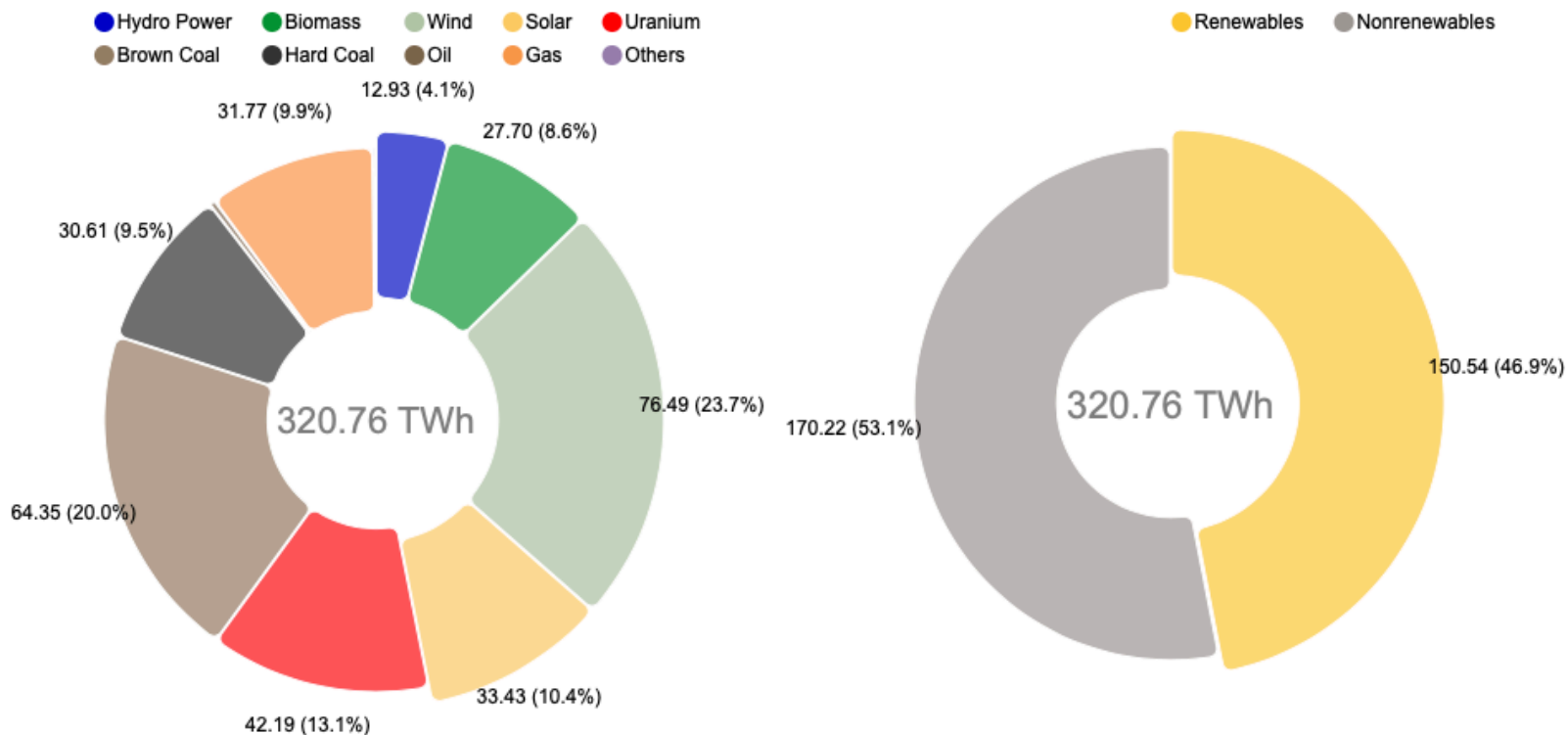
month:

week:

day:

print

usage tips



Net electricity generation of power plants for public power supply.
 Datasource: 50 Hertz, Amprion, Tennet, TransnetBW, Destatis, EEX
 Last update: 13 Aug 2019 12:20



Germany: Renewable Energy at a Record High



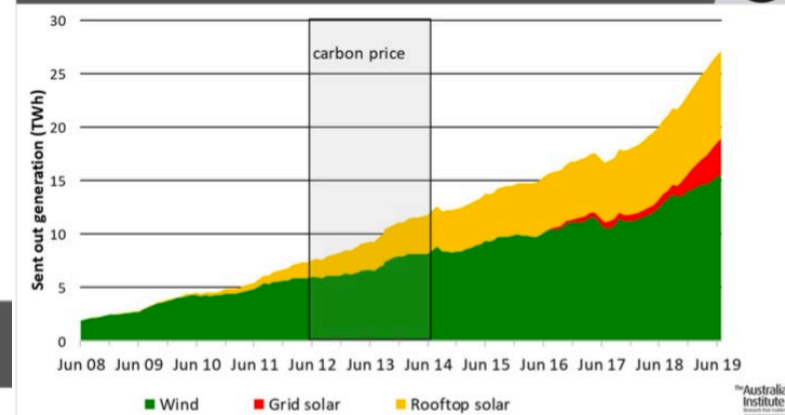
- YTD 2019, renewable energy contributed a record 46.9% of net electricity generation across Germany (with VRE at 34.1%).
- A new German monthly record high of 54.6% of total generation was set in March 2019, well on track to achieve its target of generating 65% of its electricity from renewable sources by 2030.
- Cumulative installs of large scale batteries across Germany more than doubled in 2019 to reach 371MW.
- By the end of 2018, some 120,000 households and commercial operations had already invested in solar integrated battery systems.
- Germany is developing hydrogen & RE-to-gas technology for long term storage & demand-supply management.
- Germany is also undertaking the world's first commercial scale deployment of DRM technologies in the aluminium smelting industry, a smelter with the equivalent of a virtual battery of 2,000MWh.



Australia: Renewable Energy at a Record High

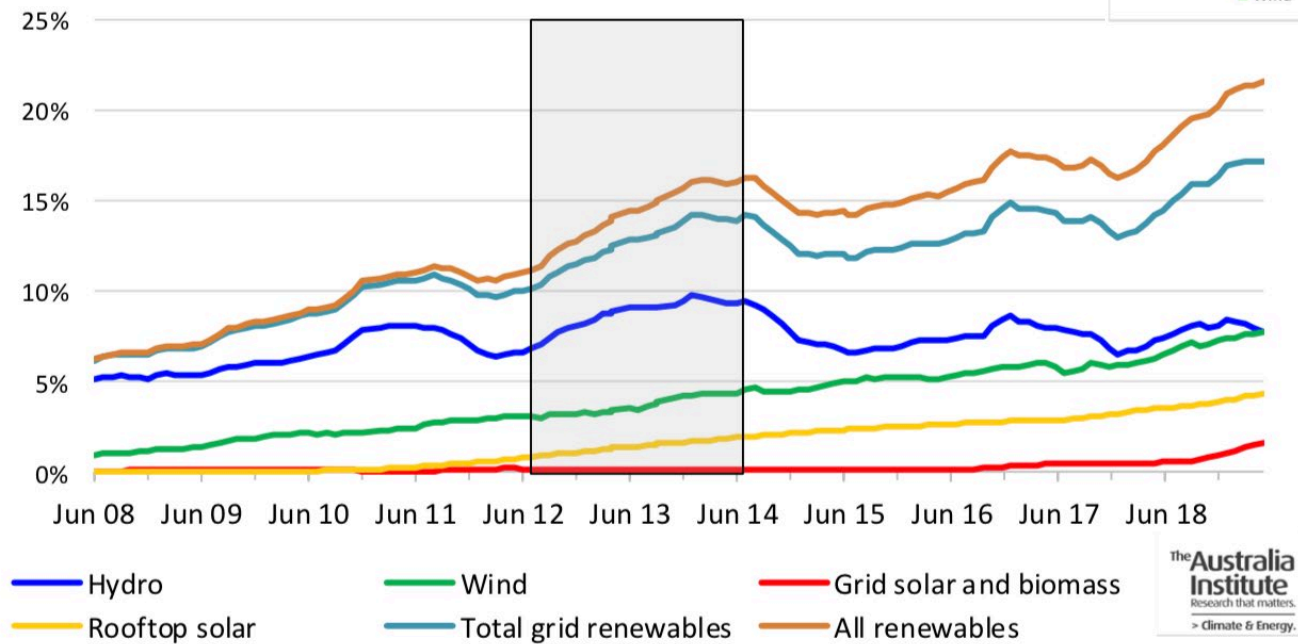


Annual "new" renewable generation by type, stacked format



In South Australia, VRE represented 48.9% of total generation in the 12 months to July 2019.

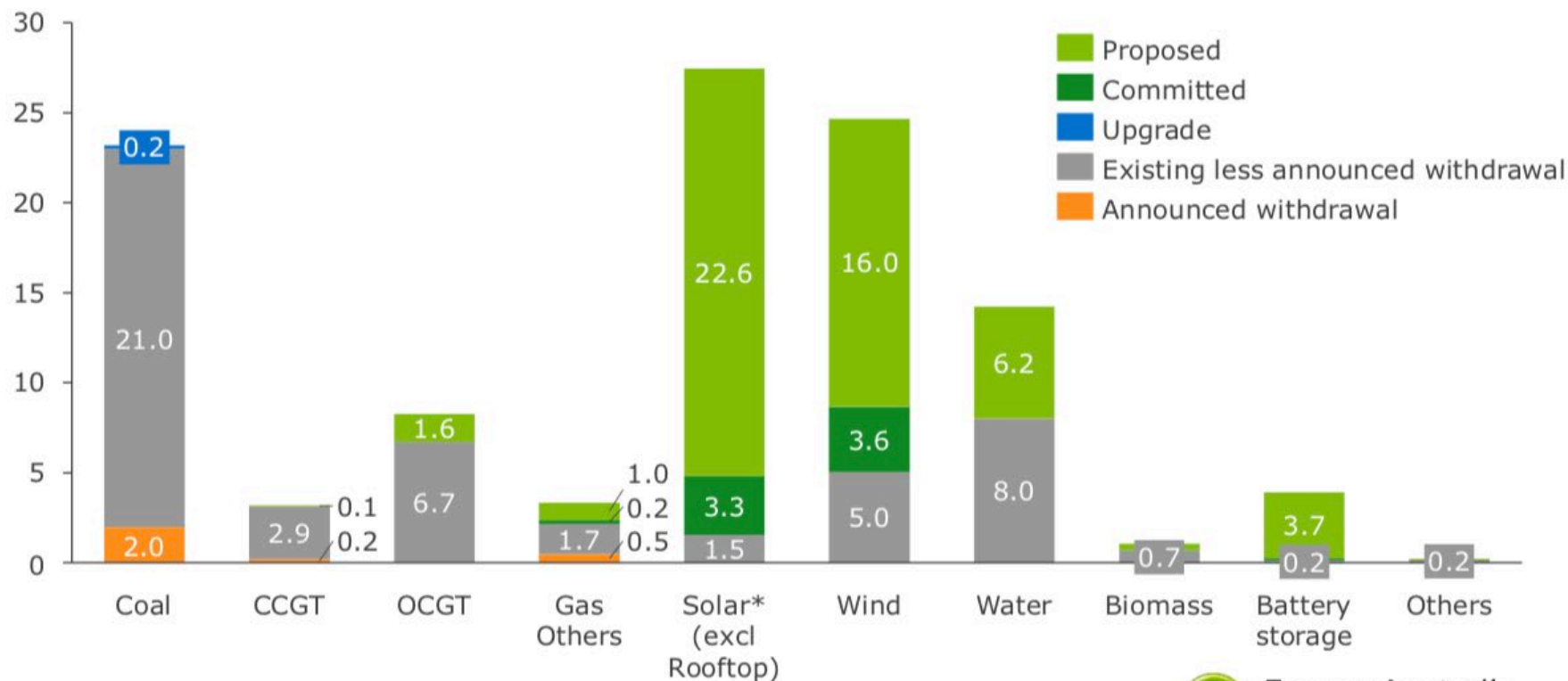
Annual renewable shares of total generation by generation type



Australia: Renewable Energy at a Record High



Existing generation fleet and proposed new generation



Note: Data as at Feb 2019. * Solar excludes rooftop PV installations
Source: AEMO generation information



Australia: Renewable Energy at a Record High



- In the year to July 2019, RE contributed a record 23.1% of net electricity generation across Australia (with VRE at 15.8%).
- In South Australia, VRE generated 48.9% of total generation.
- The Australian Energy Market Operator is developing long term thinking with its electricity Integrated System Plan for a massive uplift in interstate grid connectivity while also enabling VRE hubs.
- Australia is evaluating a massive expansion in PHS: US\$4bn Snowy 2.0 of 2,000MW/350GWh; Hydro Tasmania's Battery of the Nation of up to 2,500MW/30GWh; and six private projects of 200-250MW each.
- Batteries are being expedited, both utility scale and behind the meter, to go with 2GW of annual rooftop solar adds.
- CSP, gas peakers, virtual power plants and DRM are all being added.
- Alinta Aug'2019: expects to close 1.1GW Loy Yang B lignite power plant 15 years ahead of its 2047 closure plan due to ever lower cost VRE.

Time of Day Price Signal

- In all markets, either government balance sheets and / or time-of-day price signals / Time of Use are needed to incentivise peaking power technology deployments to complement ever lower cost VRE.

Thank You