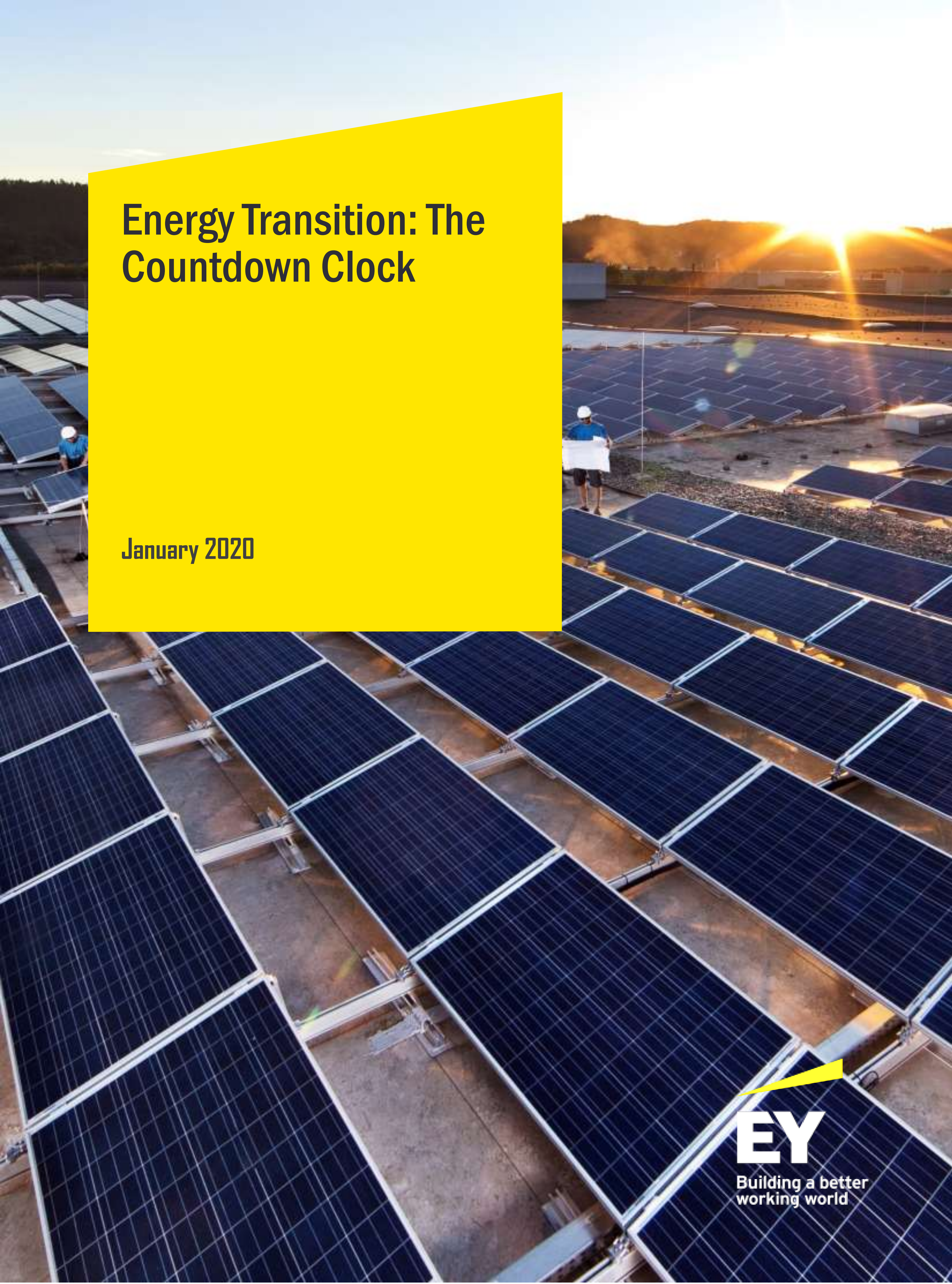

Energy Transition: The Countdown Clock

January 2020

Building a better working world

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Introduction: Setting the context for energy transition

1.1 The energy transition pathways are rapidly evolving driven by technological innovation and falling costs

The energy industry globally (including India) is in various stages of transformation driven by 3Ds – decarbonization, decentralization and digitalization. Power sector is leading the ongoing energy transition driven by rapid decline in renewable electricity costs, particularly wind and solar power generation. The infusion of renewables, complemented with storage is already nearing grid parity. In addition, rising electricity consumption in new areas such as mobility, cooking, industrial process heat, etc. is creating opportunities for more dynamism in the electricity markets.

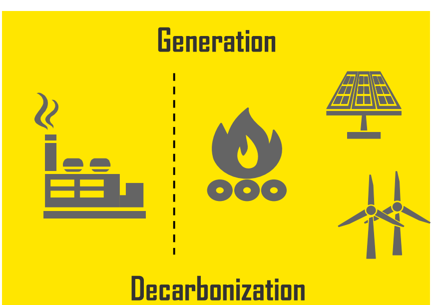
In India as well, the power sector stakeholders, particularly the electric utilities across generation, transmission & distribution (GT&D) segments, will be on the front line bracing the impact of clean energy disruption and innovation. While clean energy investment has witnessed fast growth, it is also limited by inertia of incumbent players, traditional processes and business models.

Turning disruptive threats into growth opportunities, testing new and innovative business models, initiating reforms and restructuring are the key imperatives. The Power & Utilities sector is approaching an important cross-road and therefore needs to consider many different futures to inform its purpose and strategic priorities.

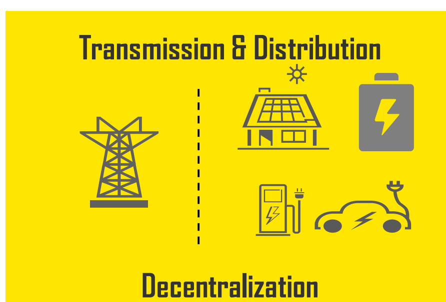
Moreover, the clean energy transitional challenges are diverse and cannot be addressed by discreet efforts at individual stakeholder level. The lack of integrated planning approach is resulting in the lost opportunity of developing integrated solutions, driving coordinated efforts and achieving synergistic outcomes that have the potential to deliver cross cutting impact and benefits.

> We should leave fossil fuels before it leaves us – IEA
>
> While energy transition is a shared concern among countries, progress will be a function of decisions taken within national settings reflecting specific social, economic and political priorities – World Economic Forum

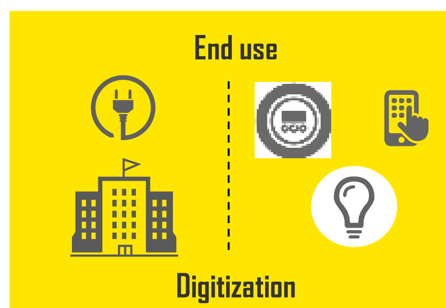
> Planning for sustainable future pays off. Long term integrated planning is more cost effective than reacting to the challenges that can arise from clean energy transition – IRENA



- Bioenergy – biomass to power
  - Bagasse cogeneration
  - Other Biomass
  - Waste to energy
- Hydropower
- Solar Photovoltaics (PV)
- Concentrated Solar Power
- Wind Power
  - Onshore
  - Offshore
- Solar Wind Hybrid
- Ocean Wave/Tidal Energy



- Rooftop Solar PV, Building Integrated PV, Battery storage (behind the meter and grid scale)
- Solar agriculture pumps
- Renewable based mini and micro grids
- Combined Heat & Power
- Energy Efficiency in buildings, industry, infrastructure and appliances
- Electrification of mobility and industrial heat (fossil to electricity; fossil to hydrogen)



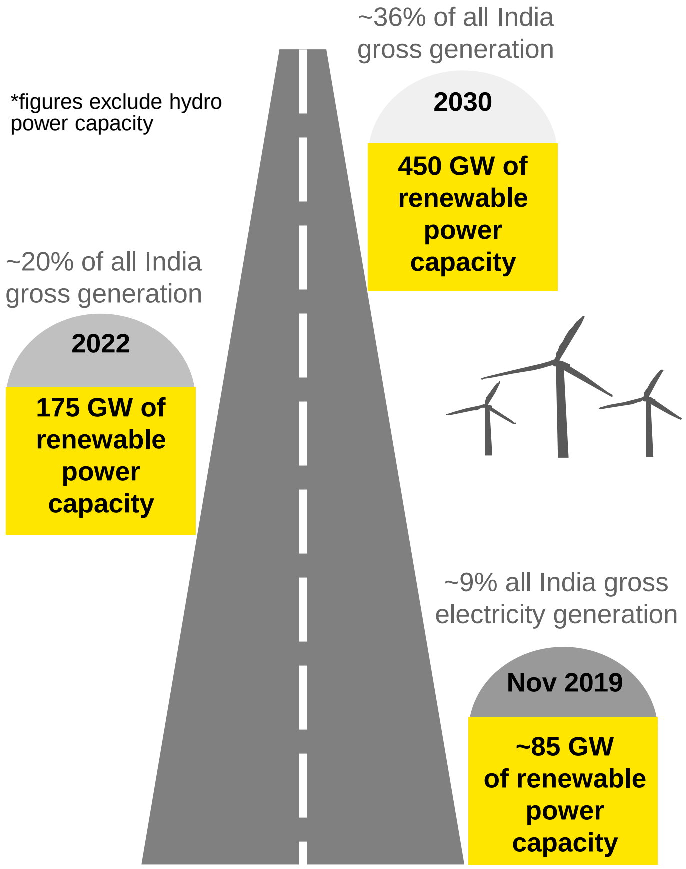
- Smart meters & AMI
- Demand response
- Internet of Things
- Home and Building Energy Management Systems
- Smart EV charging systems

*digitalization solutions for GT&D segments (e.g. AGC, SCADA, DMS, OMS, GIS etc.) will further integrate power system and accelerate the transition

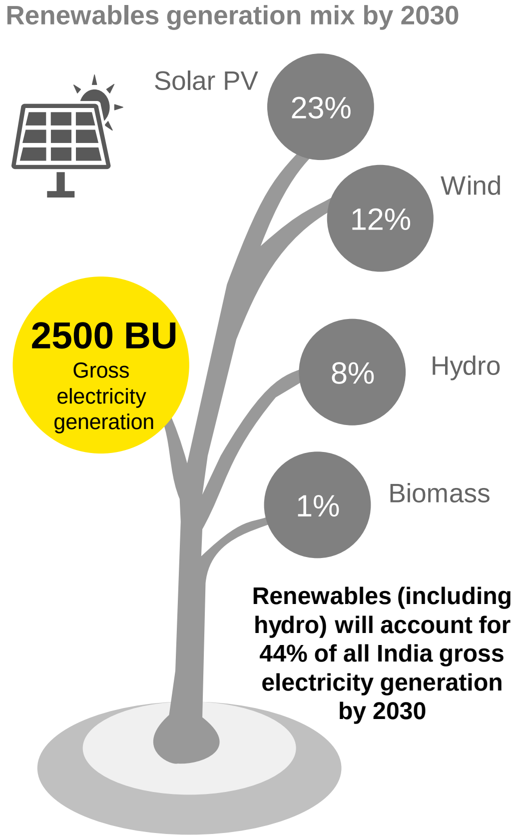
1.2 Renewables will continue to be the fastest growing sources of power generation through 2030

India aims for 175 GW of cumulative power generation capacity from renewables by 2022. This is nearly 2 times the current installed capacity of ~ 85 GW (as of Nov'19). Further, the CEA estimates that by 2030, the cumulative installed capacity from renewables could reach ~450 GW (excluding hydro), accounting for 54% of the all India power generation capacity.

The private sector investment will be central in building the new capacity. The sector has developed aggressive financing mechanisms and is mobilizing massive amounts of capital despite recent investment saturation. Auctions will be the preferred mode of capacity addition in future. As the share of solar and wind power generation rises, flexibility to cope with the variability and uncertainty will determine the pace of their addition.



Source: CEA & MNRE 2019



Source: Optimal Generation Mix for 2030, CEA 2019

Establishment of gigawatt and megawatt scale solar parks may continue to be the dominant mode of deployment for solar power in the next decade. Solar parks are integrated facilities built by pooling land and evacuation infrastructure together and enable solar power deployment to become a plug and play affair. Currently about 42 solar parks with a cumulative capacity of 23 GW have been either operational or in the process of getting established across 17 states. Solar power park developers along with land are identified and capacity allotted.

Solar and wind hybrid projects will gain momentum for efficient utilization of transmission infrastructure and land, reduce the variability in renewable power generation and achieve better grid stability. The existing policy seeks to promote new hybrid projects as well as hybridisation of existing wind/solar projects integrated with energy storage solutions.

Reasonably priced grid scale energy storage solutions will determine the pace of solar and wind power capacity addition beyond 2022. The CEA's optimal generation mix assessment estimates 136 GWh of energy storage capacity by 2030 to help integrate the increased share of renewables. Pumped hydropower is a proven cost effective energy storage solution globally, but its deployment could be limited because of competing uses, such as irrigation. A national policy mission is underway for promoting manufacturing, deployment, innovation and cost reduction of energy storage solutions. Additionally, a transition to some form of time-of-day pricing at the wholesale or retail level is recommended in National Electricity Plan (by CEA) to create self-sustaining markets for energy storage solutions.

Key policy instruments driving the energy transition in Power & Utilities sector

NDCs under Paris Climate Agreement	• Lower emissions intensity of its GDP by 33-35% compared to 2005 levels by 2030 - 21% reduction already achieved from 2005-14. • Increase total cumulative electricity generation from fossil free energy sources to 40% by 2030 - ~20% is the current share of energy mix from fossil free sources
RE capacity addition targets under National Solar Mission	• 175 GW renewable energy capacity by 2022 (100 GW Solar, 60 GW Wind) • 450 GW RE by 2030 • ~84 GW is the current installed capacity of renewable energy
Renewable purchase obligations	• 21% of procurement to be from renewable energy sources by 2022 by all state electric utilities and captive consumers • Solar (10.5%) and Non-solar (10.5%) targets notified for compliance
Reverse auctions	• Transition from feed-in-tariff based procurement to auctions with reverse bidding helped achieve lowest tariffs and competitive procurement
Solar park infrastructure support	• A plug and play concept for developers to de-risk land acquisition and evaluation infrastructure • 42 solar parks approved with a capacity of ~23 GW
Must run status for Solar and Wind	• To minimize curtailment, Solar and wind power installations enjoy must run status for power scheduling and dispatch as per the Indian Electricity Grid Code
Open access waivers for corporate procurement	• Open access waivers for corporate procurement of renewable energy has encouraged many leading companies transition to clean energy mix and save on energy costs
De-risking payment security	• The emergence of SECI, NTPC, EESL and other national players as demand aggregators and traders has helped de-risk the payment security for investors and project developers
Green energy corridors	• Interstate and intrastate transmission infrastructure capacity addition to integrate new renewable energy capacity addition in resource rich states – AP, Gujarat, Rajasthan, Maharashtra, HP, Karnataka, and TN
Net metering regulations for rooftop solar	• Nearly 29 states adopted the Model Net Metering Regulation 2013 keeping in mind the changing landscape for rooftop solar energy. CAPEX and RESCO models are largely the dominant business models so far but new utility centric business models will drive the future capacity addition.
Unnat Jyoti by Affordable LEDs for All (**UJALA**)	• World's largest LED lighting program with over 36 crore LED lamps, 71 lakh tubular lamps and 23 lakh BEE 5 star ceiling fans distributed across the country
Kisan Urja Suraksha evam Utthaan Mahabhiyan (**KUSUM**)	• Component-A: 10 GW of decentralized ground mounted grid connected renewable energy power plants for land owning farmers. • Component-B: expand energy access for 1.75 million marginal farmers by replacing existing diesel pump sets with standalone solar powered agriculture pump sets. • Component-C: energy independence of 1 million grid connected agriculture consumers by promoting adoption of solar powered irrigation pump sets.

2

The Countdown Clock for Energy Transition

2.1 Understanding the tipping points for decarbonisation of power generation system

We are moving toward a new energy system, augmented and interconnected by digital technologies, where power and information flow in both directions. Generation is becoming more decarbonised, distributed and closer to the end consumer. Decarbonisation of power generation system from renewable energy sources will unfold/materialise through four disruptive "tipping points". Understanding the when, what, and how of the tipping points creates opportunities for electric utilities and other stakeholders.

Tipping points for decarbonisation of power generation system in India

1 | VRE reaching parity with new coal station

The cost of power generation from VRE reaches parity with the newly built coal power plant (fixed plus variable cost)

2 | VRE displacing existing coal generation

The cost of power generation from VRE reaches parity with fuel (variable) cost of existing coal power plants

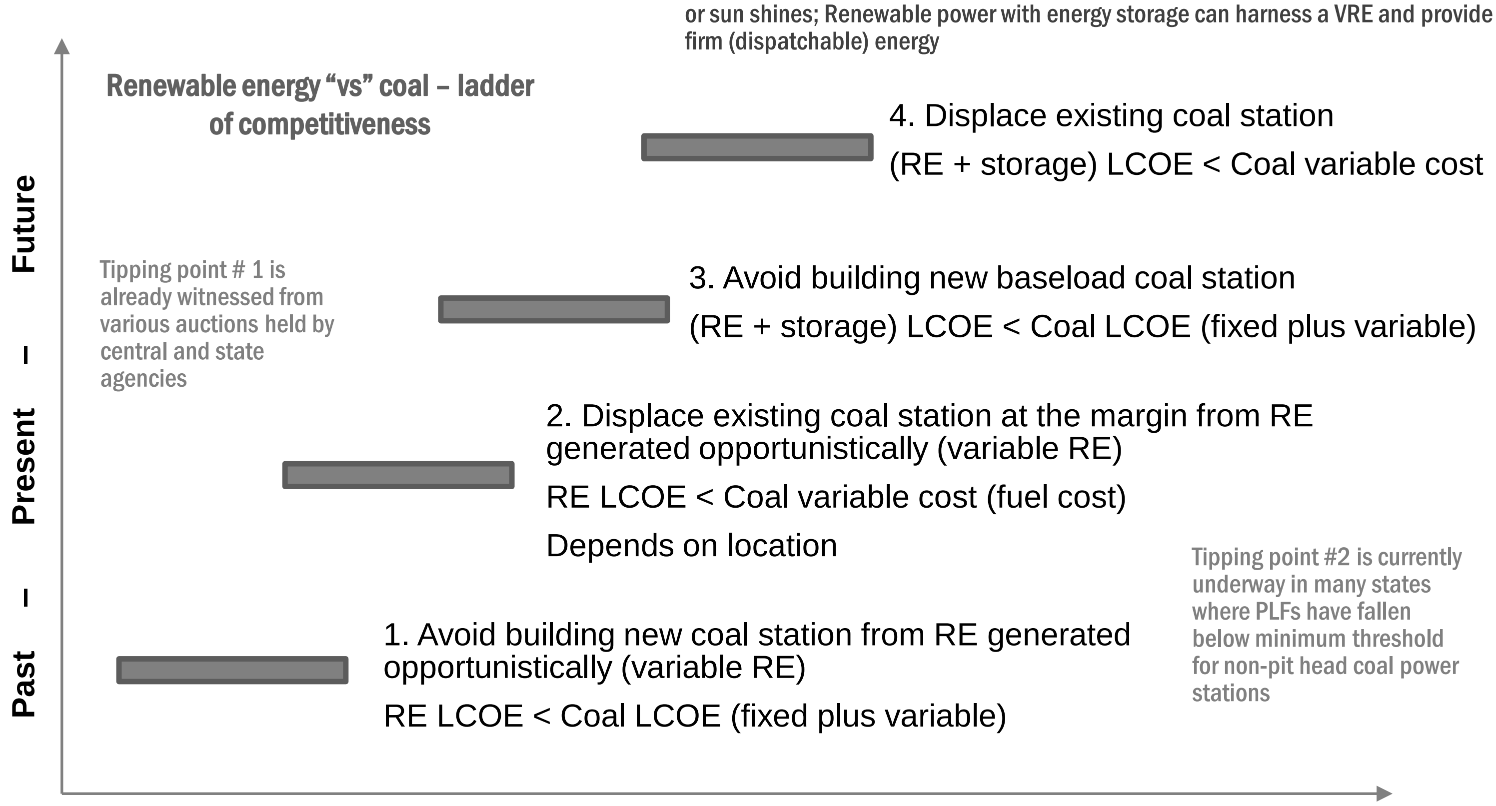
3 | VRE plus storage reaching parity with new baseload coal station

The cost of power generation from dispatchable renewables (e.g. solar PV plus storage) reaches parity with newly built coal power plant (fixed plus variable cost)

4 | VRE plus storage displacing existing coal generation

The cost of power procurement from dispatchable renewables reaches parity with fuel cost of existing coal power plants

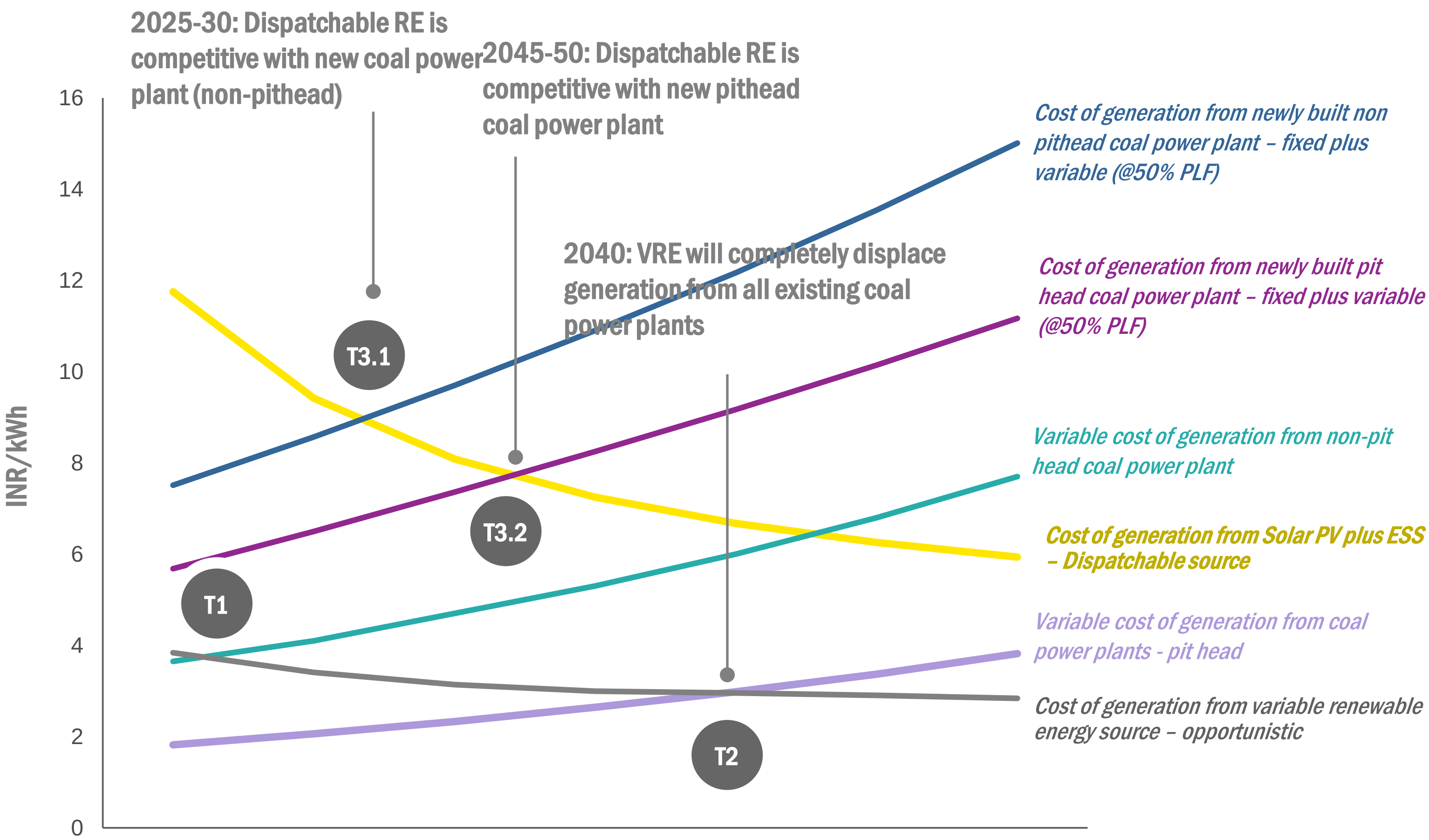
*VRE: Variable renewable energy generated opportunistically when the wind blows or sun shines; Renewable power with energy storage can harness a VRE and provide firm (dispatchable) energy



Source: Rahul Tongia, Brookings India **Disruptive impact on utilities**

2.2 The Countdown Clock for Decarbonisation

Competitive advantage coupled with innovation will drive solar and wind power installations beyond their potential. Together with cost effective energy storage solutions (ESS), they will displace coal based generation and dominate the power supply mix through 2050. Dispatchable renewables, especially Solar PV integrated with energy storage solutions (ESS) at the generation site is expected to become competitive with new coal power stations (non-pithead) before 2030 and pithead stations before 2035. Variable renewable energy sources with opportunistic generation is already displacing the existing coal power plants (non-pithead) at the margin and by 2040, it is likely to displace generation from all operating coal plants including pithead stations.



Source: EY analysis

The energy transition characterised by above tipping points will pose some obvious challenges that electric utilities must address to remain relevant in the rapidly evolving environment. For example, the PLFs of coal power stations may further drop below minimum threshold as they will be become less competitive w.r.t to increasing share of VRE. The business case for new coal power stations to provide baseload will be increasingly challenged in the coming decade. Asset quality deterioration and heightened risk of NPAs / stranded assets in the thermal power generation sector is likely to be intensified, especially in the renewable resource rich states.

Insights from EY's future energy scenario modelling in the renewable resource rich states taking into account the above countdown clock for decarbonisation:

Deep decarbonisation of power generation system will help electric utilities flatten the cost of power procurement with only a marginal increase through 2050. This can also turn around the financial health of electricity distribution companies by bridging the gap between ACS and ARR. The benefits of affordable electricity for the consumers will outweigh the costs of clean energy transition. ESS capacity addition will be determined by the quantum of daily shortfall after exhausting all available sources of energy and inter day / seasonal load variability. Coal's share in the overall power generation mix will peak in 2025 and gradually diminish through 2050. Post 2035, both coal and gas based thermal power generation will compete to become the bridge source serving the evening shortfall that will likely persist even after the time shift of excess renewable energy by ESS. The quantum of capacity addition required from these sources will be largely determined by ramping requirements.

2.3 The Countdown Clock for Decentralisation

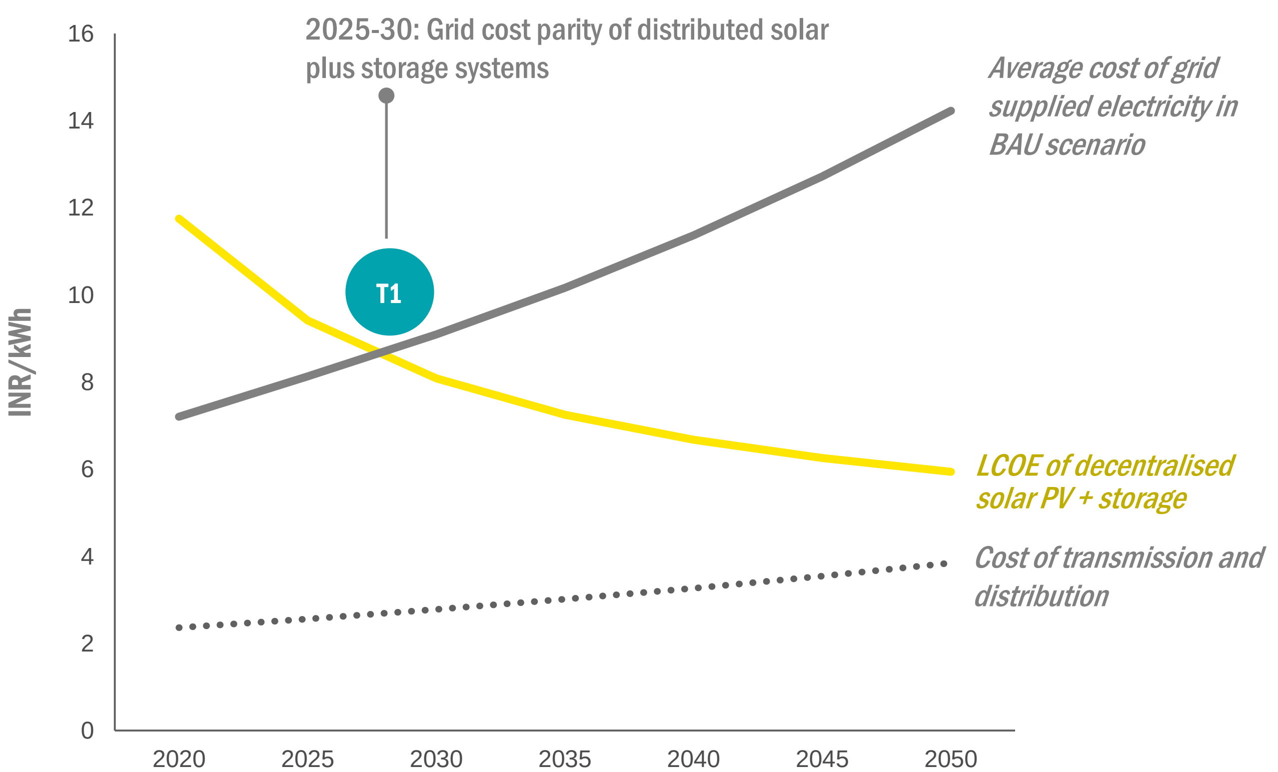
Decentralisation of power generation system will unfold/materialise through three disruptive "tipping points", with renewable energy sources at the centre of this transition. These three tipping points will be felt across all functions and by all stakeholders. Understanding the when, what, and how of the tipping points creates opportunities for electric utilities and other stakeholders.

The cost of round the clock decentralised solar power generation (solar PV integrated with ESS) for self-consumption will reach parity with grid cost of supply before 2030. Commercial & Industrial consumers, especially with predominantly day operations, will find DRE solutions more competitive than grid supplied electricity in the next 2-3 years.

Consumers with appetite for self production of clean renewable electricity will migrate from centralised power supply/grid supply. The power generation ecosystem will be increasingly distributed and closer to the end consumer. This is a tremendous opportunity for electricity distribution companies for turning disruptive threats into opportunities through new service-oriented, value-driven business models. Time of day retail tariffs enabled by smart meters can be a powerful incentive to establish commercial frameworks and capture value in these emerging markets.

Tipping points for decentralisation of power generation

Tipping point		
Tipping point 1 "Grid cost parity" of non-utility solar plus storage systems	1	**The birth of the new energy system**
Tipping point 2 The price of battery electric vehicles reaches cost parity and performance parity with Internal Combustion Engine (ICE) vehicles	2	**Electricity and mobility industry convergence**
Tipping point 3 The cost of transporting electricity exceeds the cost of generating and storing it locally	3	**The digital energy market place**



Source: EY Analysis

3

Energy transition led opportunities in the Power & Utilities sector

3.1 Turning disruption into opportunities

Clean energy transition in the utility scale power generation value chain would require lakhs of crores of capital investment towards adding giga/mega watt scale solar PV and wind power systems, cost effective energy storage solutions by electric utilities. This has immense potential to create ~~lakhs of~~ direct jobs and local value creation in the sector. Accelerated transition would ensure a more secure, cost-effective, efficient and environmentally sustainable energy mix, while also combating climate change and air pollution threats.

However, distributed generation will take up increasing share of electricity demand in future. Specifically, distributed solar power generation will grow to contribute substantially more than utility scale systems. Solar powered irrigation will be one of the largest sources of distributed generation driven by increasing market share of solar powered irrigation systems and agriculture feeders. Rooftop solar capacity addition will be primarily driven by residential consumers, corporate procurement and favourable cost economics.

DISCOMs must evolve from electricity supply companies to becoming energy service companies with strong revenue streams in the distributed energy sources and associated ancillary services. They must continuously test and scale up innovative service oriented business models to compensate for revenue loss from defecting consumers and find value in the emerging distributed energy markets. Comprehensive reforms are required to restructure electric utilities and enhance their capabilities in this transition.

Solar powered off-grid solutions will rapidly emerge as viable alternatives for several livelihood applications promoting a sustainable rural economy. Two kinds of complementary solutions are emerging in this context:

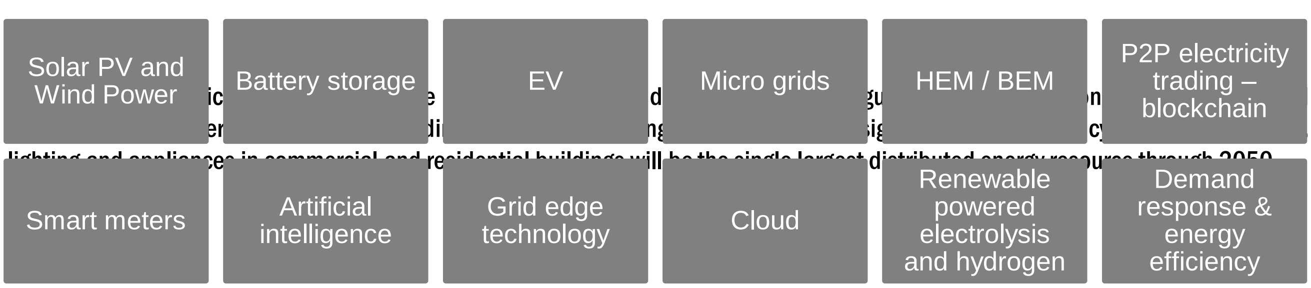
i. Product innovations for livelihood applications, which can use electricity efficiently and effectively

ii. DRE-powered innovations that can bridge gaps in the centralised electricity supply system and power income-generating activities in rural areas

These innovations are already beginning to transform lives among rural population by increasing productivity and product value, reducing input costs and drudgery. A 2018 study by CEEW estimates about USD 13.2 billion market for 14 key DRE powered rural income-generating activities, which constitute about one-third of the 34 million micro-enterprises in rural India. These include custom tailoring, beedi manufacturing, restaurants, retail shops, hairdressing, flour milling, furniture manufacturing, jewellery making, poultry raising, sweetmeat making, and vehicle repair. The estimated market size pertains to the value of energy efficient appliances running with DRE (solar and battery) in these markets.

Apart from this, growing number of corporate customers are likely to enter into renewable PPAs to adopt high share of clean energy as their source of electricity. Corporate renewables deals is one of the important and principal driver for accelerating renewables share in the overall energy mix. Growing EVs will bring new load to the system which may not coincide with renewable energy generation without smart grid technologies.

Renewable powered electrification of industrial heat is one of the key emerging transition pathways to decarbonise industry that is otherwise hard. However, total decarbonisation of this sector, particularly that requires high-grade heat may be difficult purely by means of electrification. Hydrogen produced from renewable electricity through an electrolyser could be cost effective & facilitate the integration of high levels of VRE into the energy system. Hydrogen could be the missing link in the decarbonisation of industrial heat. Key hydrogen technologies are maturing. Scale-up can yield the necessary technology cost reductions.



3.2 Role of smart grids and digitization in accelerating the energy transition

Digital grid supported by a two-way communications can provide **insight and control** into the operations, empowering utilities to partner with end consumer and better respond to disruptive challenges

Industry challenges

- Aging infrastructure
- Financial constraints
- Increasing customer expectations
- Reliability performance
- Integration of renewables
- Safety concerns
- Resource constraints

Smart capabilities

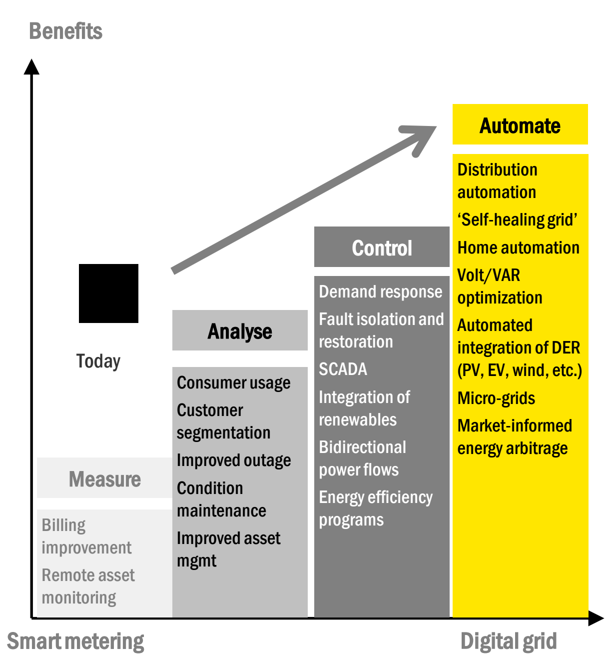
- Smart meters
- IT / OT integration
- Analytics & Big Data
- Digital platforms & social media

Benefits

- Deferral of capital expenditures
- Reduced operational expenditures
- Improved power quality
- Greater compliance with regulations
- Reduced technical network losses
- Increased resource efficiency
- Reduced risk of critical asset failure
- Greater revenue protection capabilities
- Reduced customer churn
- Increased customer consumption congruence with RE generation

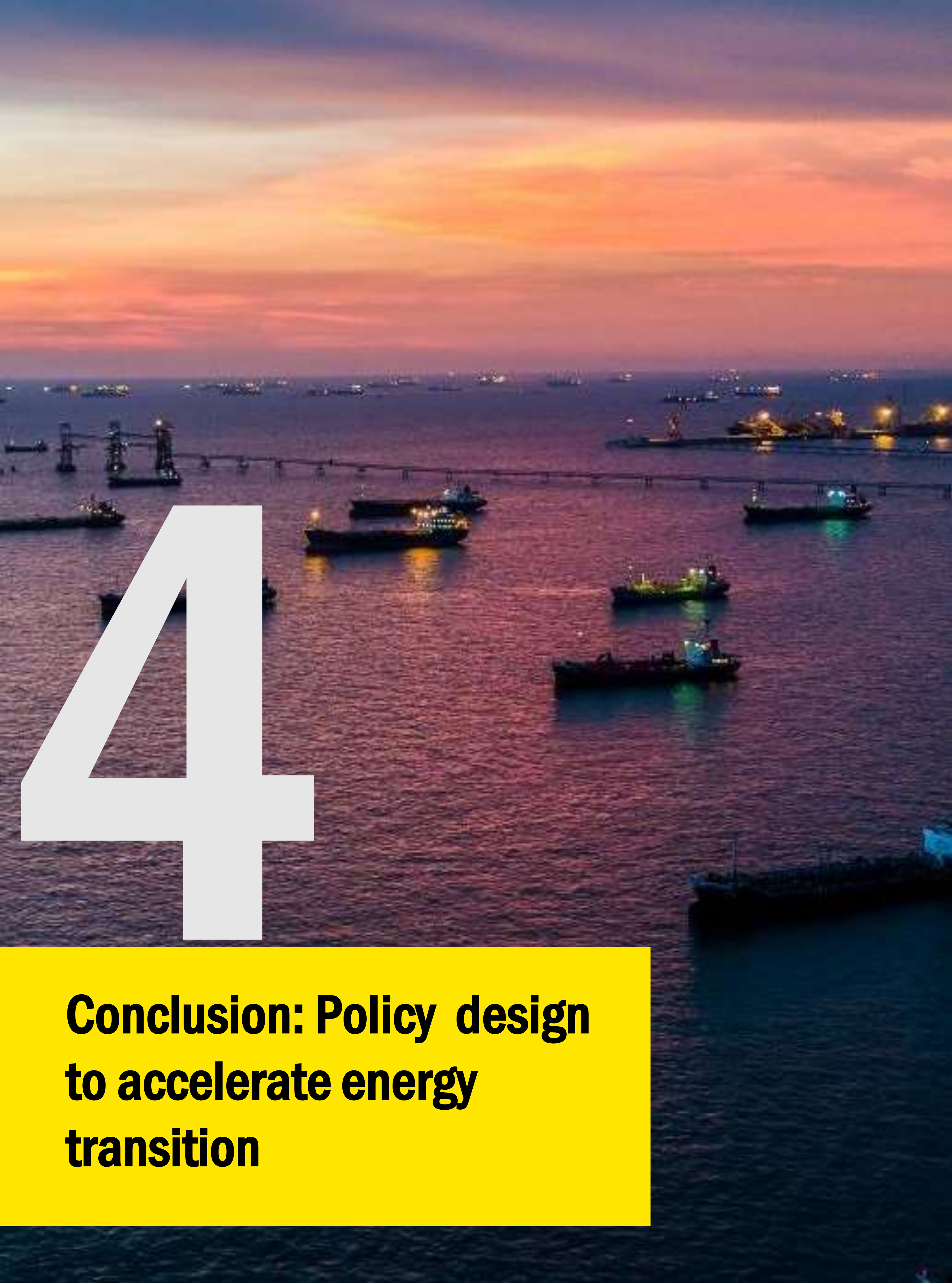
✓ Regulatory compliance
✓ Operational efficiency
✓ Customer satisfaction
✓ 'Future-proofing' the grid

Digital grid evolution anticipated for India



Benefit category	Example of benefits	Incremental benefits of integration
Defer network investment	► Peak reduction through price-induced Demand response	► Peak reduction through direct load control
Optimize asset utilization	► Predictive asset analytics	► Risk-based maintenance enabled by asset sensors
Improved network reliability	► Level outage alerts	► N/w fault identification, isolation and rerouting ► GIS-tagged assets
Loss reduction improvement	► Source-to-meter loss analysis ► Customer load profiles	► Volt/VAR optimization
Improve DER integration	► Net metering ► Improved view of demand	► Remote and automated DER management ► Remote voltage regulation
Improve EV integration	► Optimize EV rate case	► Opportunistic grid-charging stations

Source: EY Analysis



4

Conclusion: Policy design to accelerate energy transition

4.1 Policy recommendations for accelerating energy transition

Periodic revision of wind and solar power resource assessment to reflect technology advancements and emerging use cases

Government resources and institutions should be strengthened to establish and maintain a technical resource library, data bank, or an information centre to periodically collect and correlate information regarding solar and wind resource potential. The resource assessment should taking into account technology advancement, innovation, emerging use cases, land resource availability, etc.

For example, remote sensing technology has proven its ability to measure wind resource at higher heights.

Power market restructuring to promote time of day wholesale and retail markets

Long term PPAs constitute 90% of power procurement portfolio. They treat all kWh the same, regardless of when (time of day/season) they are generated. This system provides limited incentive / inadequate commercial frameworks for emerging clean energy technologies. A transition to some form of time-of-day pricing at the wholesale level could accelerate transition by encouraging development of peaking power, fast-ramping power, storage, and ancillary services such as frequency support and ramping. The retail markets should transition towards real time pricing enabled by smart grid infrastructure.

Utility anchored business models for promoting distributed energy sources

Revenue loss and grid defection of consumers are increasingly cited by electric utilities as a principal bottleneck in leading the transition towards decentralised grid and high share of distributed energy sources. To overcome this, the policy and regulatory ecosystem must promote the transformation of these utilities from being electricity supply companies to energy service companies by offering innovative products in the value chain of decentralisation and distributed energy sources.

The next generation reforms envisaged through amendments to the Electricity Act 2001 and Tariff Policy should promote this transformation. Institutional restructuring and capacity building of electric utilities should be promoted to facilitate this transition.

Facilitating the transition from baseload coal to flexible coal serving as peaking power plants

Coal ramping should increase with rising share of wind & solar. From a system perspective, cycling costs are relatively small, whereas the costs can be significant from generator perspective. Also the emission impacts of cycling coal plants are relatively small.

Capital modifications are critical, but primary savings will come from changes to operating procedures. Flexibility comes at a cost but costs can be minimized with strategic modifications and maintenance.

The policy and regulatory frameworks governing capacity additions and coal plant operations should rapidly evolve to facilitate this transition.

4.2 Policy recommendations for accelerating energy transition (cont.)

Reducing the land use impact of utility scale solar PV and wind energy systems

India has over 29 GW of ground mounted solar photovoltaics with an estimated land footprint of 58000 hectares and over 37 GW of wind power with estimated land footprint of 55000 hectares. It is envisaged that another 95,000 hectares is required to set up 53 GW of solar and wind power systems to reach the goal of 160 GW by 2022.

Both forest land and private agriculture land will be under immense pressure for power generation use in this context.

It is worthwhile to examine dual use cases of land for renewable energy generation and device policy pathways to reduce the land use impact for example Indian Railways effort for using it's land along track. Government could lead innovation competition towards research, development, demonstration and scaling up of solutions that promote dual use of land. Existing land use policies, especially leasing of revenue wasteland and semi arable lands for ultra megawatt scale renewable energy parks should also be reviewed for allowing dual use considering the fact that some states are already taking proactive steps in this direction.

Incentives to transition from fossil to electricity for industrial process heating

Electrification of industrial process heating is not only leading pathway towards energy transition but also essential for sustainable power & utilities sector. However, there are little incentives for manufacturing enterprises to switch to electricity (e.g. electric furnace, heat pumps, molten oxide electrolysis etc.). The policy and regulatory frameworks could provide fillip say by reducing the upfront cost to upgrade the electrical infrastructure (e.g. transformers etc.) in this transition. A tariff structure with equal emaphasis, if not more, on Reliability and Flexibility vis~a~vis KVAh could be missing link.

Building energy productive and efficient smart villages / panchayats / taluks / districts

The policy focus on promoting standards and recognising / making conscious villages/panchayats / taluks / districts in line with Smart cities towards the energy needs of inhabitants and work positively towards influencing the value chain an make a big difference. The smart integrated and sustainable solutions can minimize external dependencies for energy.

The administrative heads could lead and facilitate a multi-stakeholder platform involving officials from electric and water utilities, municipalities, large consumers and enterprenures to come together in the development and management of energy productive and efficient communities.

5

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