International Energy Agency

# Status of Power System Transformation – Policy, market and regulatory frameworks to support power system flexibility

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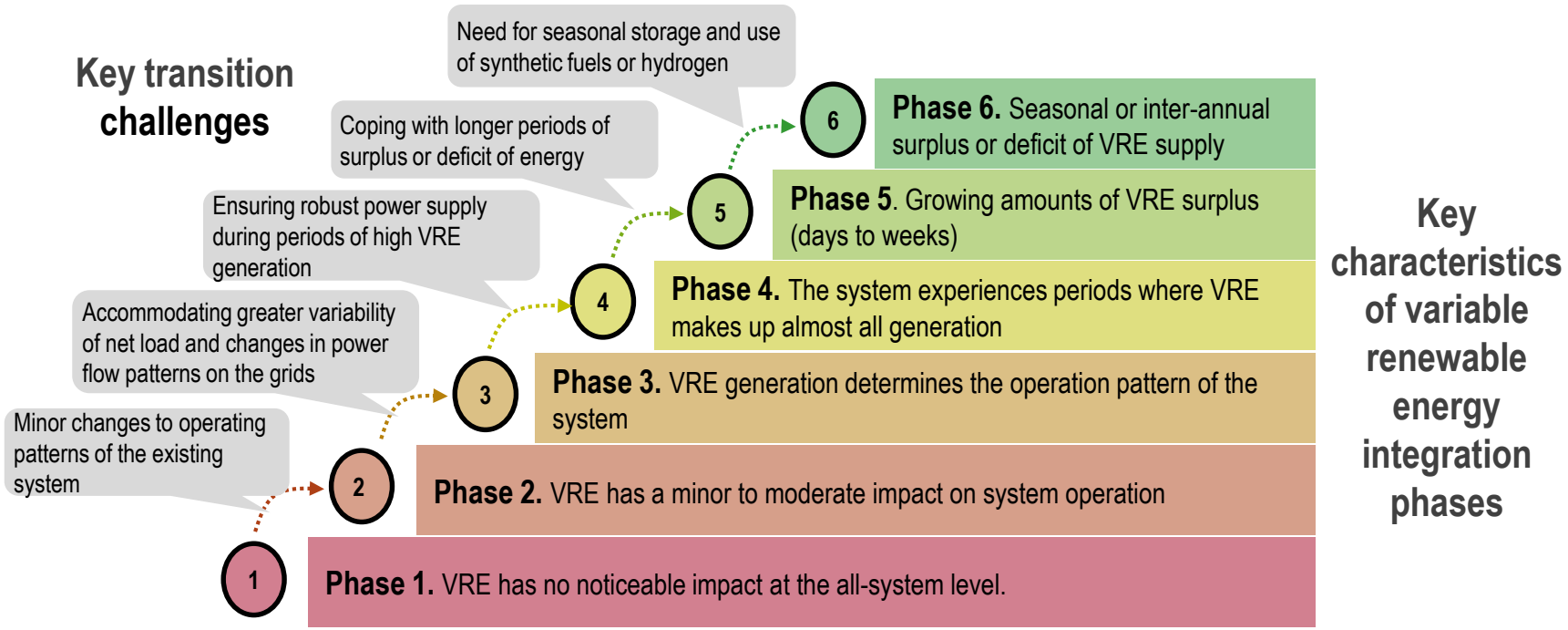
IEA

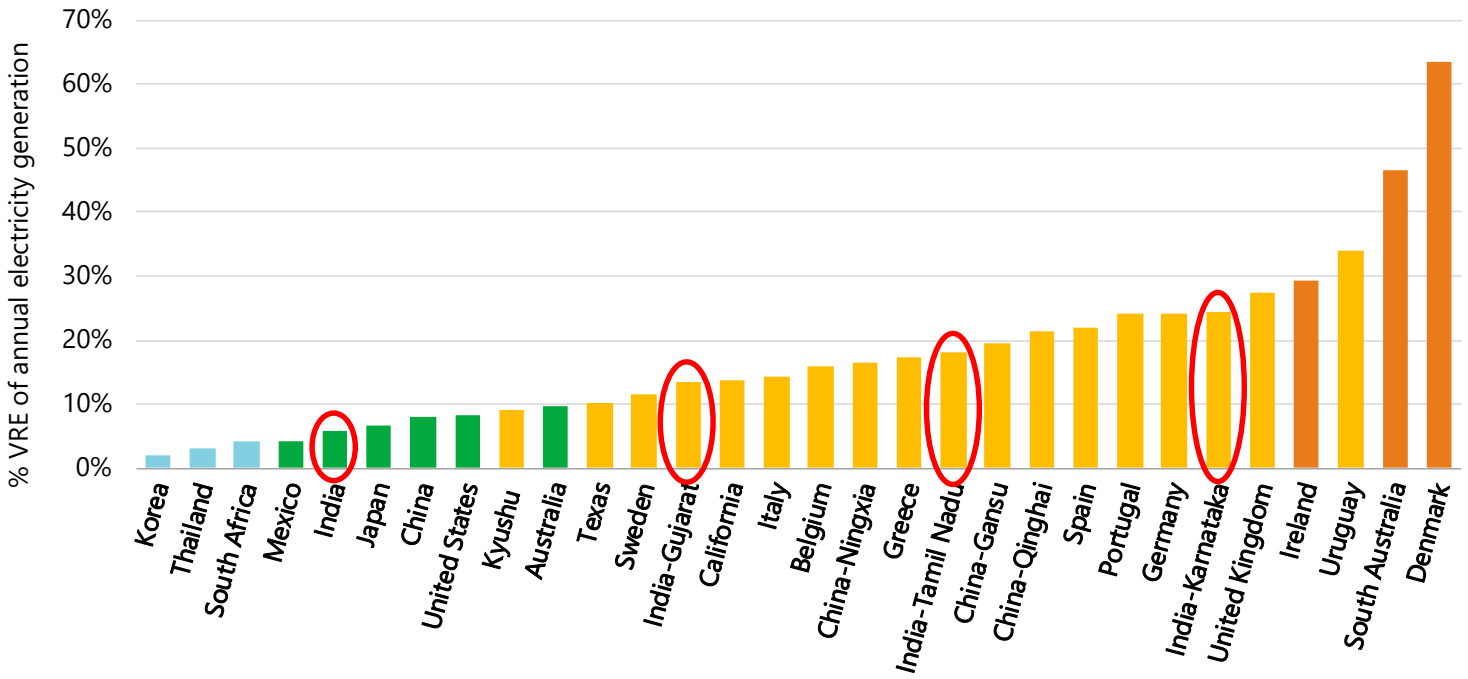
# Key transition challenges in different phases of integration




**Key challenges in each phase that should be addressed for moving up to higher phases of variable renewable energy (wind and solar) integration**


Source: World Energy Outlook 2018

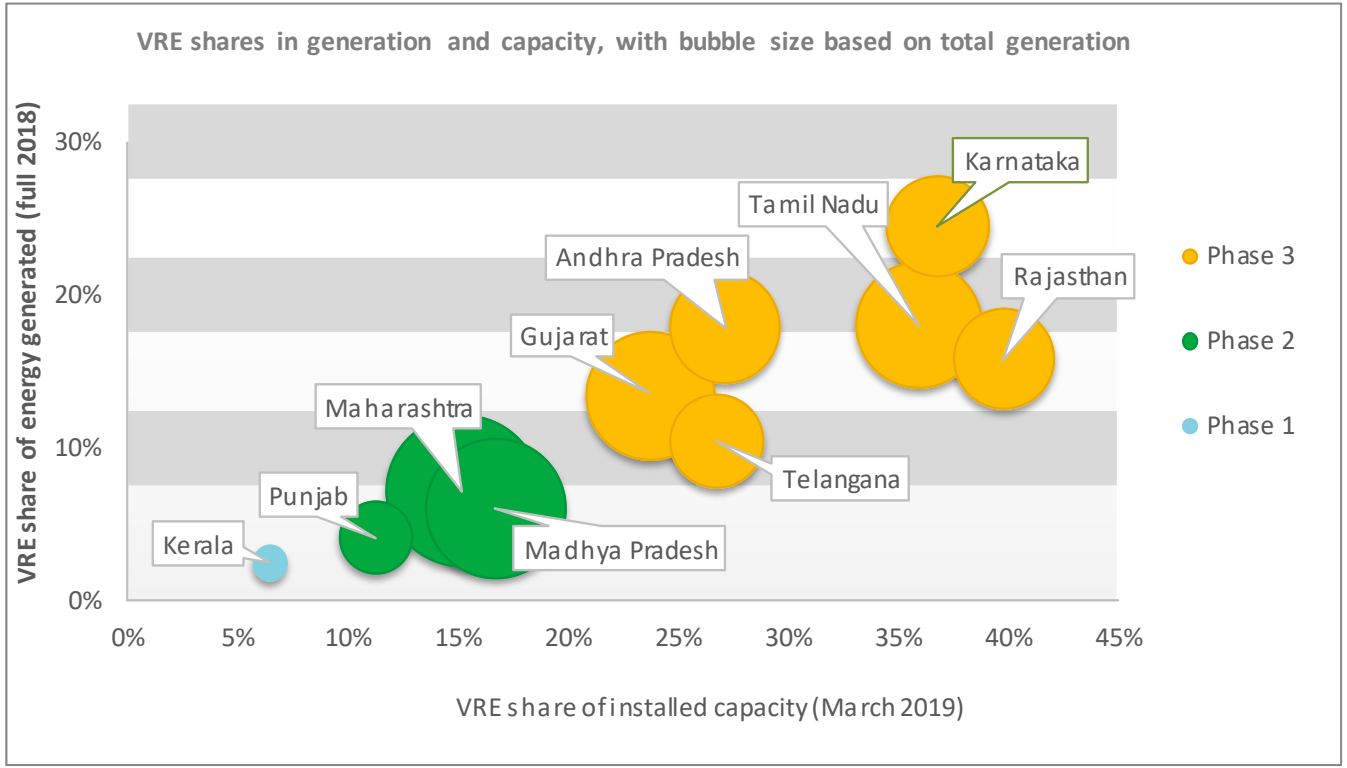
# System integration: different phases




- Phase 1 - No relevant impact on system
- Phase 2 - Minor to moderate impact on system operation
- Phase 3 - VRE determines the operation pattern of the system
- Phase 4 - VRE makes up almost all generation in some periods
- Phase 5 - growing amounts of VRE surplus
- Phase 6 - seasonal or inter-annual surplus or deficit of VRE supply

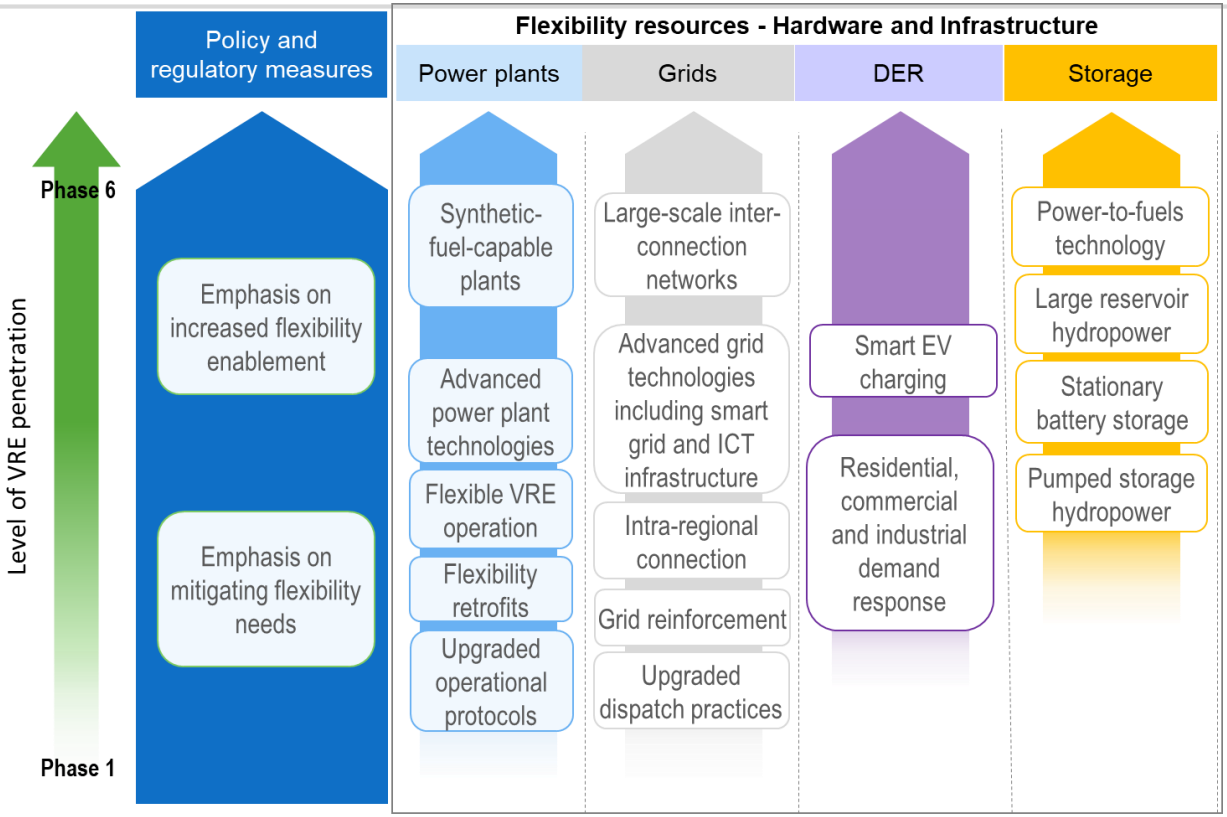
**Globally most regions remain in phases 1 or 2. India's rapid energy transition already places some states in phases 2 or 3, while global examples of regions in phases 3 and 4 demonstrate a diversity of measures that can accelerate VRE integration.**

# System integration: different states in India are in different VRE phases



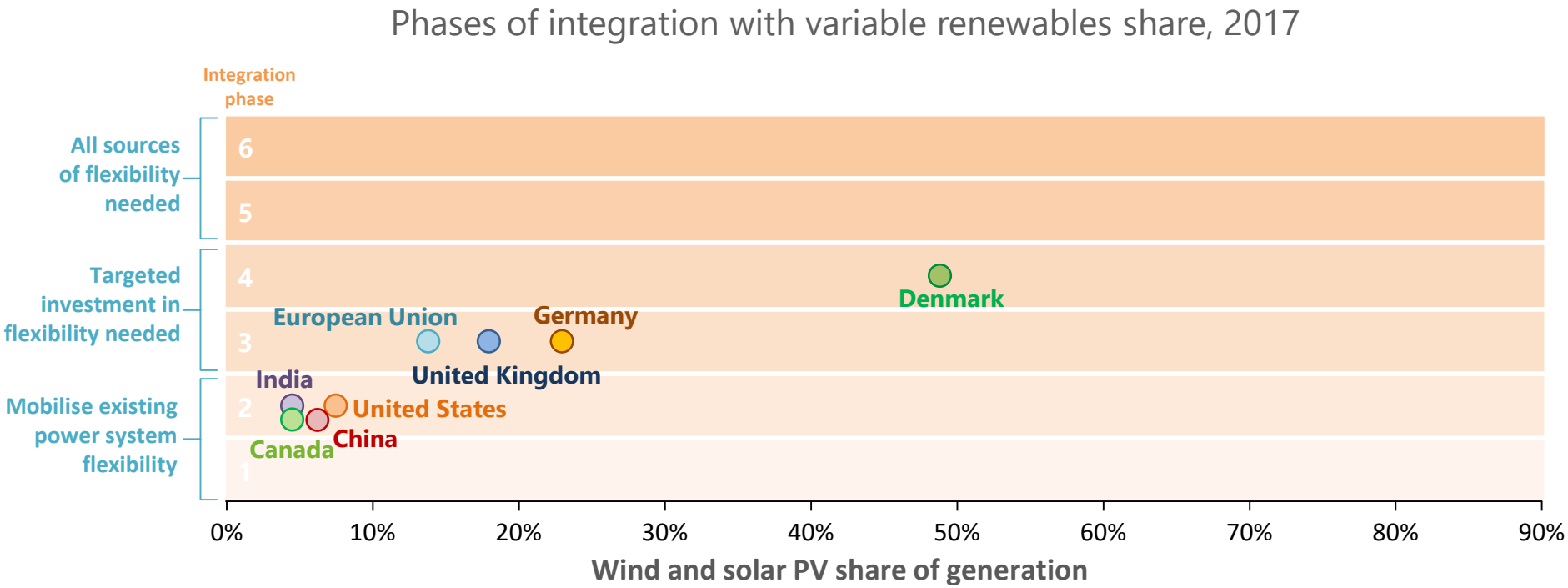

**Some states in India are already seeing renewables integration phase 3, where VRE generation determines the operation of the system, and can be expected to enter higher phases in the coming years. Flexibility options are key to managing increasing variability: flexible power plant operation, transmission, demand side response and energy storage.**

# Flexibility options for VRE integration




**Flexibility resources can mitigate the challenges from VRE integration in different phases and allow the system to integrate more VRE**

# Flexibility is the cornerstone of tomorrow's power systems




**Very high shares of wind & solar PV require reforms to attract investment at unprecedented level in grids & interconnections, flexible power plants, affordable storage & demand-side response**

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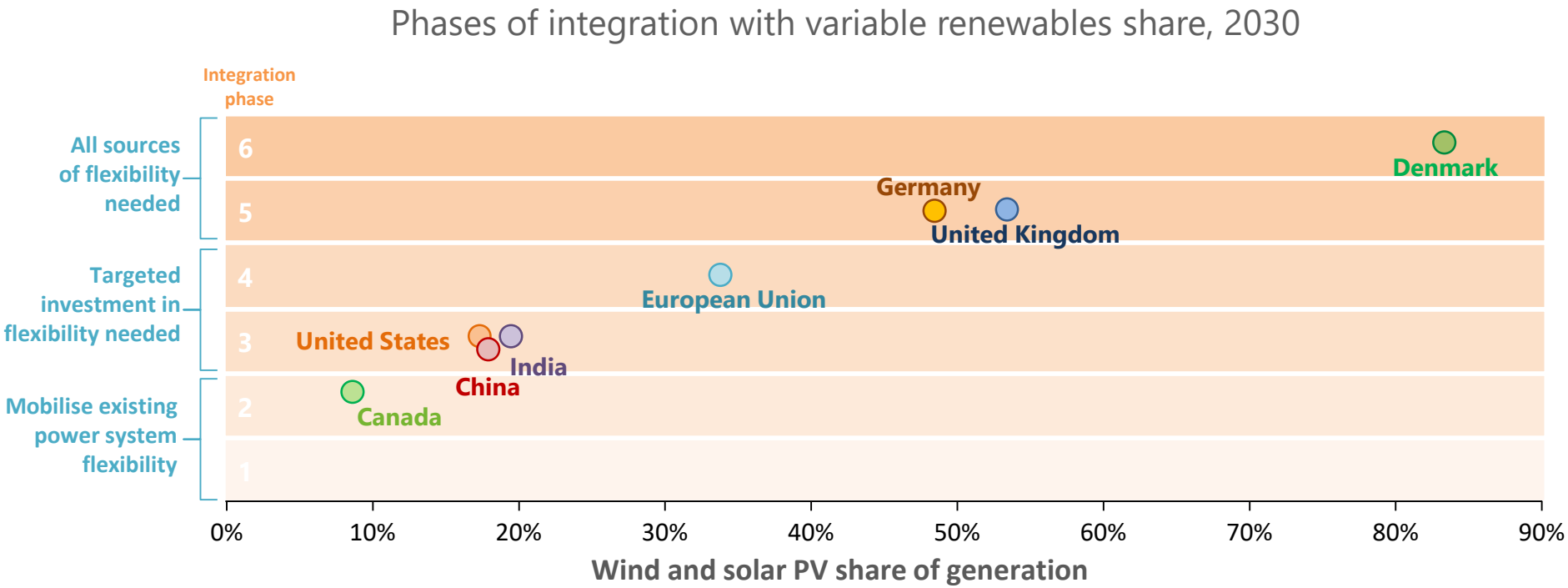
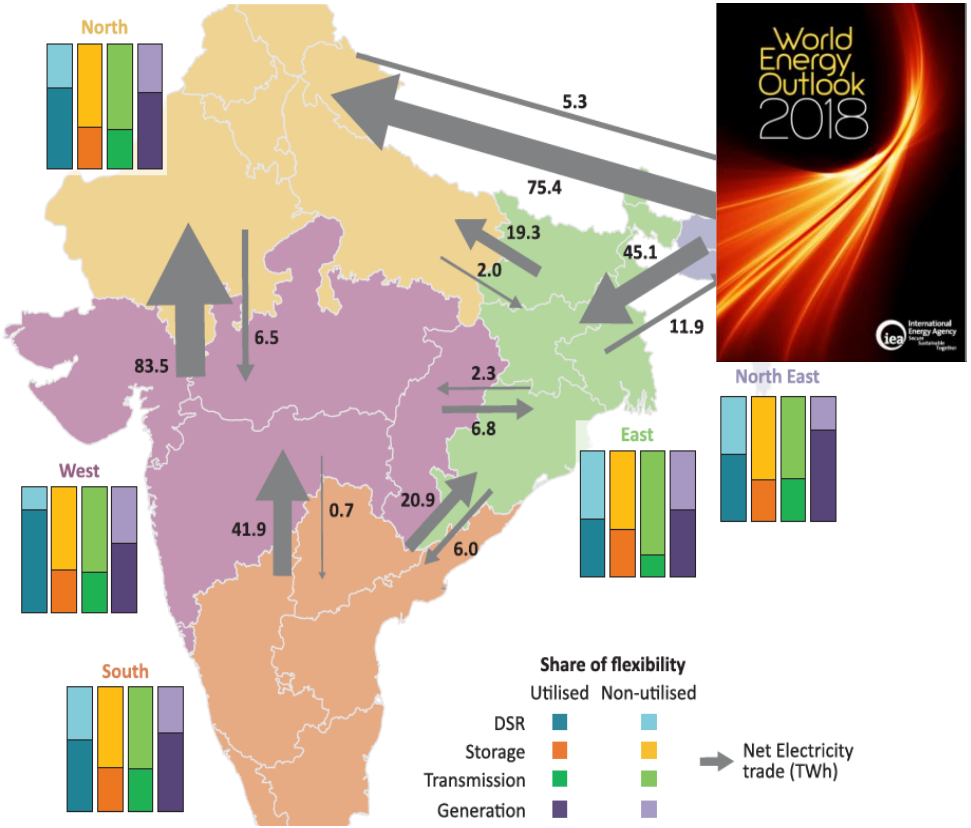



**Very high shares of wind & solar PV require reforms to attract investment at unprecedented level in grids & interconnections, flexible power plants, affordable storage & demand-side response**

# India – Production cost modelling to assess flexibility requirements

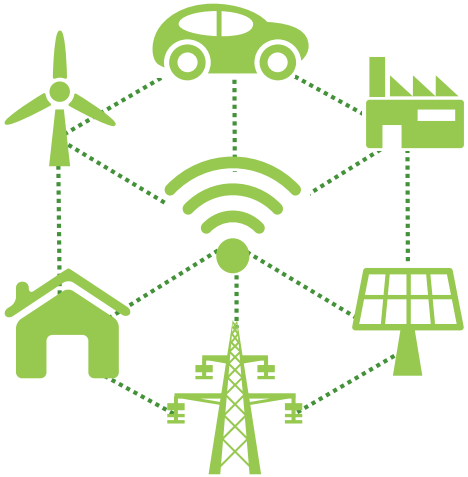
- Modelling of India's future power system to assess system flexibility requirements
  - Four main flexibility resources: *Power plants, Grids, DSR, Storage*
  - Detailed transmission elements and flow limits,
- The system uses more of its overall flexibility potential during times of **high ramping requirements**
- Generation remains the **largest source of short-term flexibility**
  - Also contribution from DSR, storage and grid




Source: World Energy Outlook 2018, https://www.iea.org/weo2018/

# Identifying and engaging with the right actor at each level is key

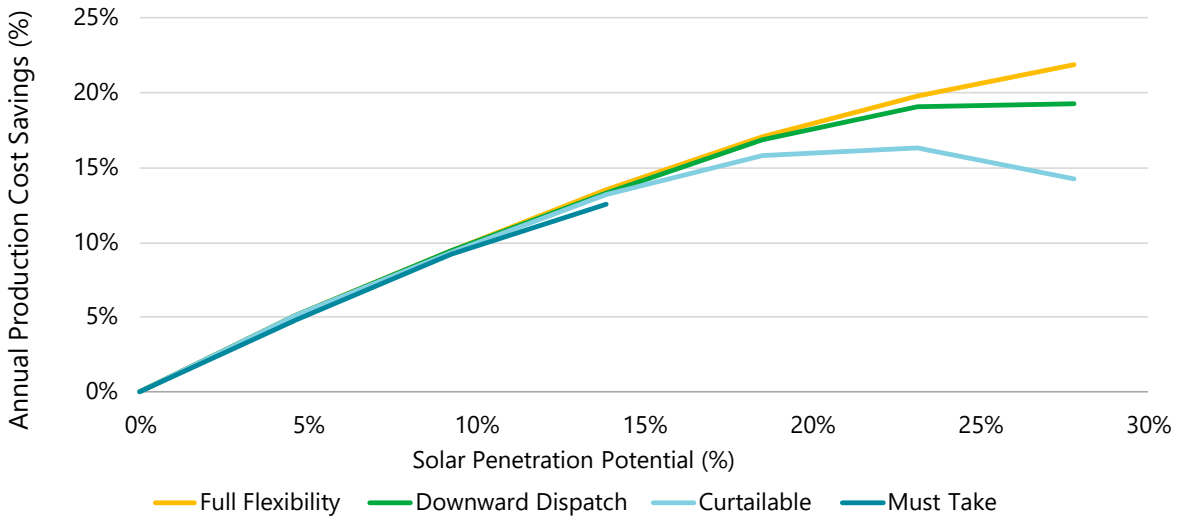
| Institutions and actors ("Who") | Policy, market and regulatory frameworks ("How") | Hardware and infrastructure ("What") |
|---|---|---|
| ***Typical decision makers*** | ***Categories of interventions*** | ***Asset types*** |
| Energy ministry | *Energy strategies*<br>*Legal frameworks*<br>*Policies and programmes* | |
| Regulatory agency | *Regulatory frameworks and decisions*<br>*Power sector planning exercises*<br>*Retail electricity pricing* | |
| System operator, electric utility, standards body | *Power market rules and codes*<br>*System operation protocols*<br>*Connection codes* | |



**The institutional context defines the set of instruments available to boost power system flexibility. Enabling new services and roles may also require rethinking the institutional framework.**

# All power system assets can provide flexibility, including VRE

- Appropriate policy, market and regulatory frameworks can enable participation from a broad range of power system assets.
  - *Example: Tampa Electric Company (USA) study on system integration of PV*

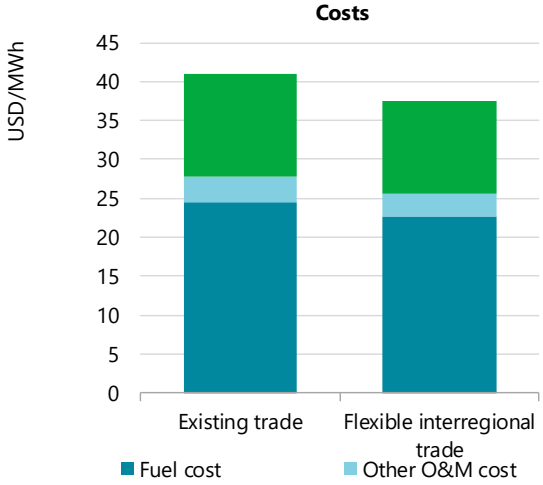


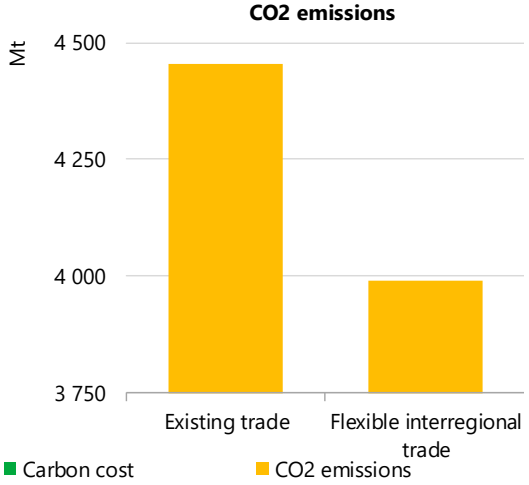

**Redefining grid codes, ancillary service prequalification requirements and remuneration schemes are needed to tap into the flexibility potential from VRE. This strongly depends on the institutional framework.**

# Electricity networks remain a critical enabler of system flexibility

- Inter-regional and international coordination can yield significant economic benefits
  - *Example: IEA China Power System Transformation study (NPS scenario, 2035)*

    *Potential for annual 36 bn USD system cost reduction (9%) with economic dispatch*

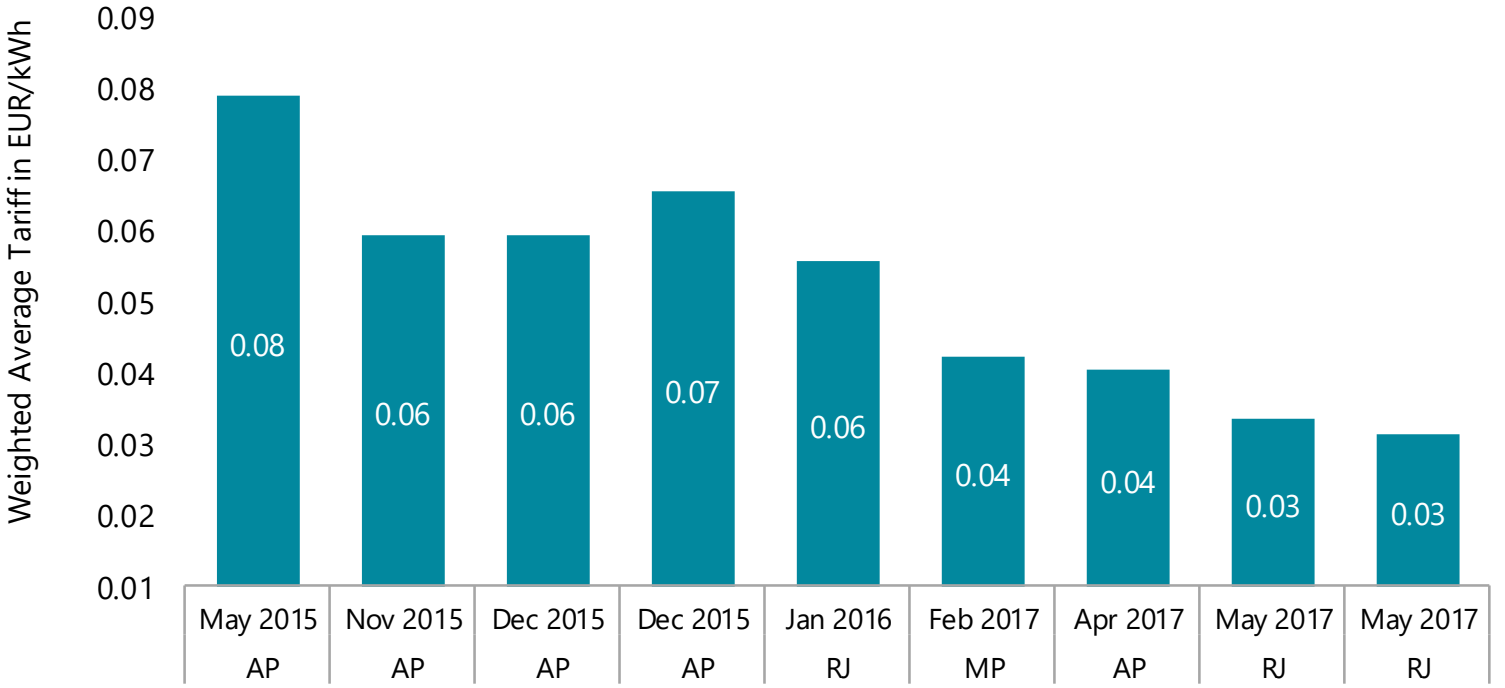



**Enhanced trade across regions can bring substantial cost savings and emission reductions by sharing flexibility resources more widely.**

# Flexibility sources: grids

## Coordinated grid and RE planning in solar parks in India has contributed to the 100 GW solar target

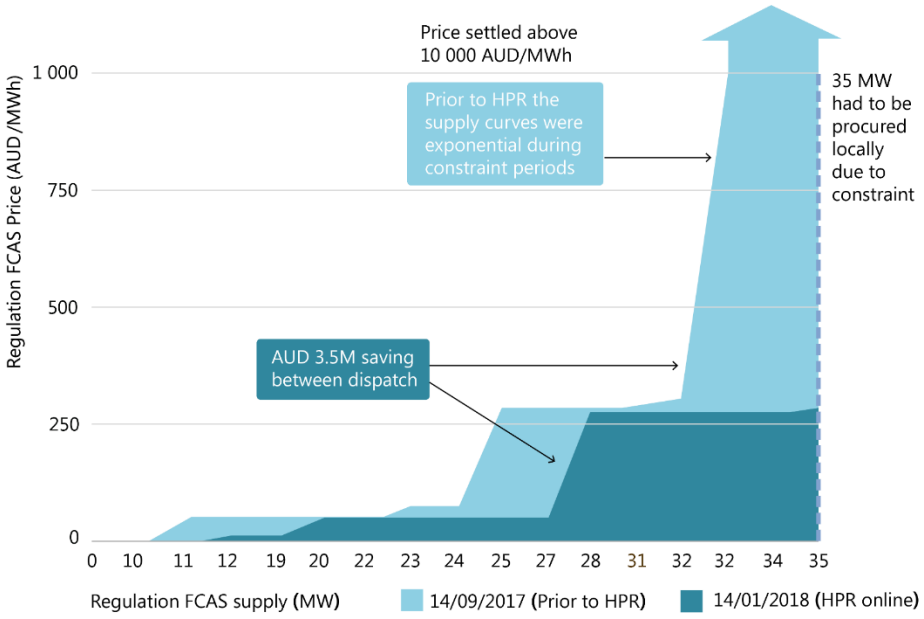



Note: AP = Andra Pradesh, RJ = Rajasthan, MP = Madhya Pradesh; each tariff refers to a different project

**Solar parks in India remove connection risk, helping to eliminate delays and reduce costs. Hybrid projects incorporating wind or storage with PV systems to reduce variability and improve flexibility are also encouraged.**

# Batteries are becoming a cost-competitive flexibility provider

- Changes to connection codes and market rules **enable participation** by energy storage resources.
- Regulatory innovation is needed to **unlock multiple benefit streams** for storage resources in a system-effective manner.
- *Example: Hornsdale Power Reserve participates in regulation, contingency reserve and energy markets in South Australia*

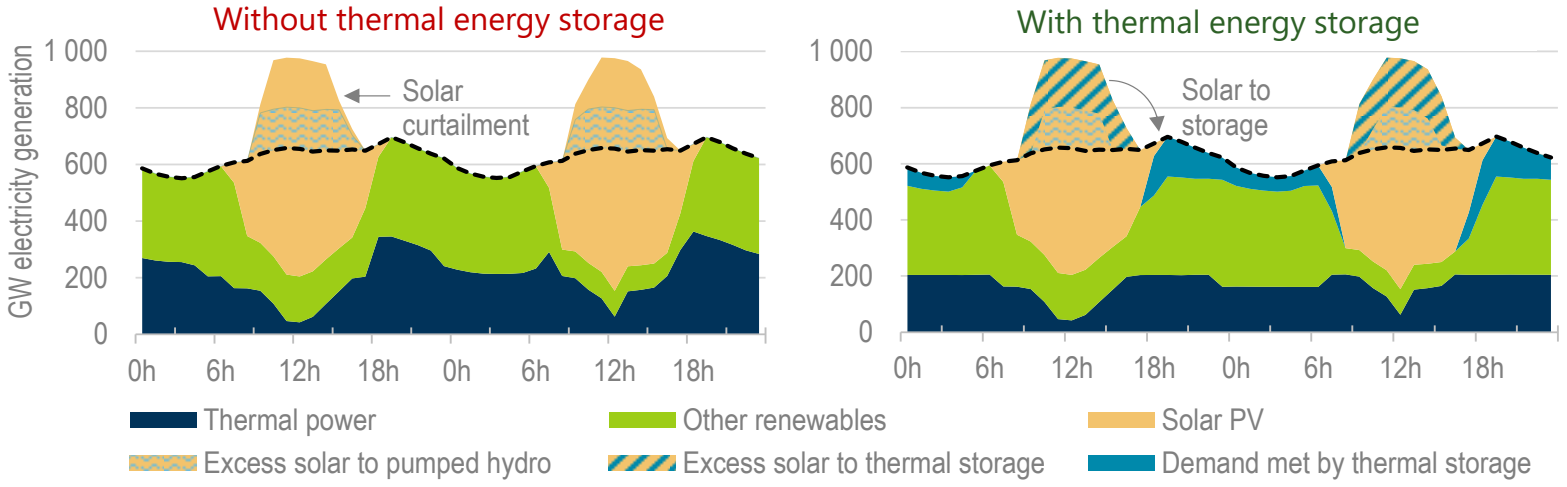



**FCAS: Frequency control ancillary services**

**Prequalification requirements and the design of flexibility services are key to enable battery storage in flexibility services. Benefit stacking can increase financial viability but requires further regulatory review.**

# Modelling example – Potential role of thermal storage in India

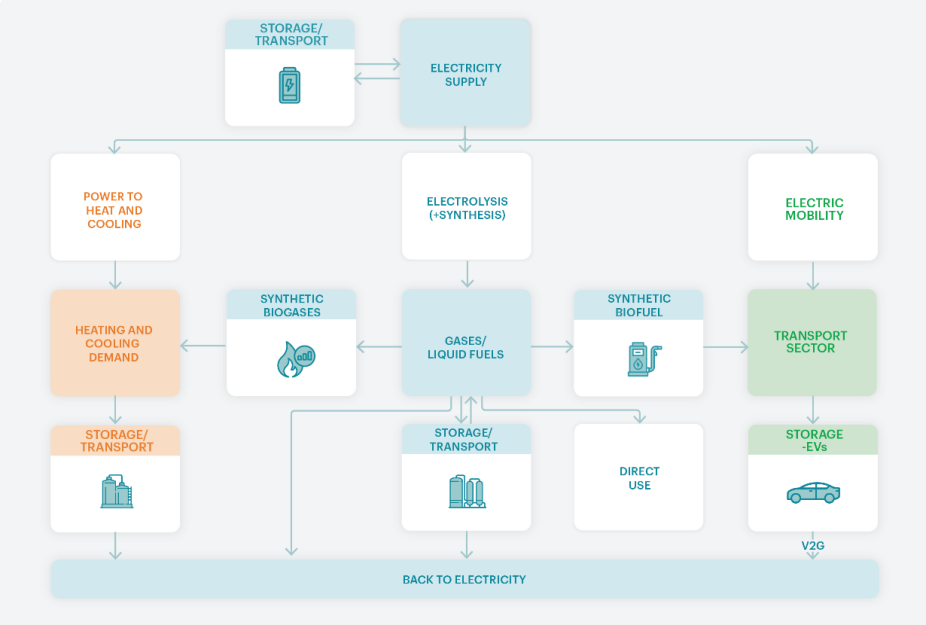
- Potential solar PV curtailment due to expected high capacity in 2050
- Cooling demand is also expected to grow substantially
  - Peaking in the evening when solar PV is no longer available
- Thermal storage could take advantage of surplus solar output to alleviate the strain of peak cooling demand on the electricity system in the evenings




Source: The Future of Cooling, https://www.iea.org/futureofcooling/

# Sector Coupling addresses wider energy system decarbonisation

- Sector coupling efforts have the potential to enroll new flexible loads at scale to enhance power system flexibility.
- As all energy sectors are impacted there is a need for coordination of economic policies beyond the power system.
- For example hydrogen or ammonia can be produced using renewable electricity and used as fuels or directly (ammonia)
- Interlinkage of taxes and tariffs between various sectors of electricity, fuels, gas and bioenergy should not become barriers for wider system decarbonisation




**A new Clean Energy Ministerial horizontal accelerator focused on sector coupling will be considered in 2019 to broaden understanding and share experiences of this trend.**

# The Power System Flexibility (PSF) Campaign Network

## Co-leads

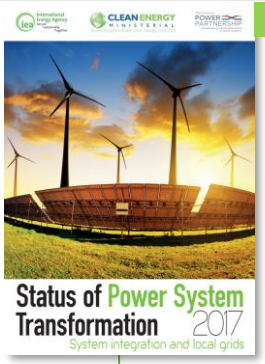
## CEM Members

## Non-government members

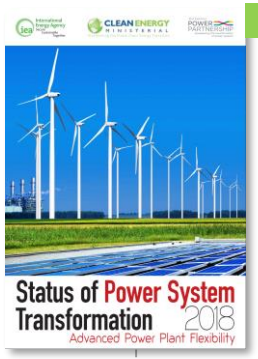
Agora Energiewende
chargepoint
COWI
EDF
ESMAP Energy Sector Management Assistance Program
epexspot
enel
ENERGINET
ENVISION
First Solar
Fraunhofer ISIT
NEW 4.0 Norddeutsche EnergieWende
GE
giz
J-POWER
KYUSHU ELECTRIC POWER CO.,INC.
MHPS
NEXT KRAFTWERKE
Ørsted
REstore
RSE Ricerca Sistema Energetico
SIEMENS
UK Power Networks
Vestas
VGB POWERTECH

**Campaign brings together a broad spectrum of actors and experiences from across the globe**

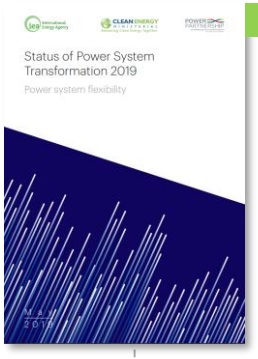
# More than 2 years of continuous work on power plant and system flexibility




CEM 8




CEM 9




CEM 10

| | CEM 8 | CEM 9 | CEM 10 |
|---|---|---|---|
| Advanced Power Plant Flexibility | Focus on thermal power plant flexibility for VRE integration | | |
| Power System Flexibility | | Focus on VRE, grids, demand response and storage for system flexibility | **Focus on digitalisation, market design and sector coupling** |

**Work on the campaign has been key to elevate innovative technical solutions to high-level policy discussions**

# Status of Power System Transformation 2019

Focus on: Power System Flexibility

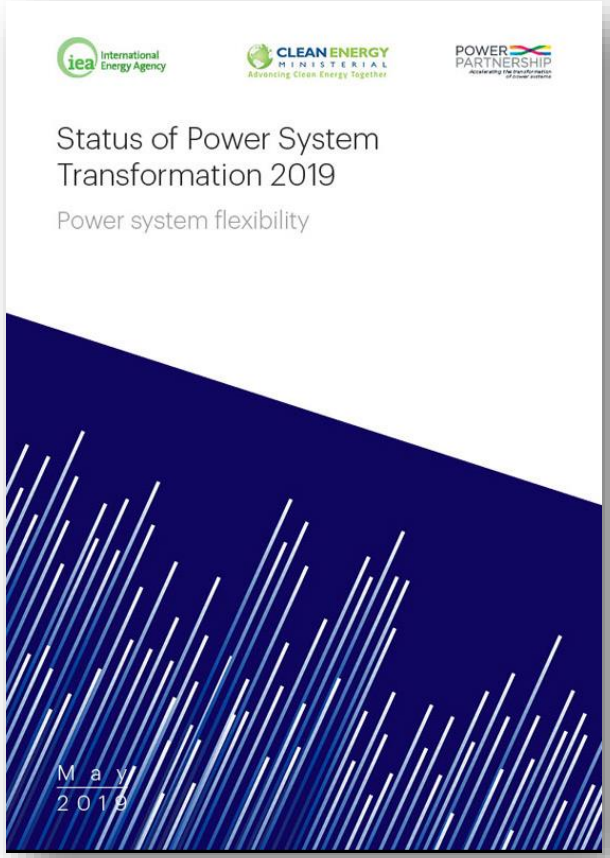
Co-authored by:

International Energy Agency

NREL Transforming ENERGY

Available at:

https://webstore.iea.org/status-of-power-system-transformation-2019



# Conclusions and the way forward (1)

- With countries continuing to move to higher shares of VRE, policy maker engagement with actors across the power system is a priority to unlock latent flexibility potential and de-risk investments.

- The cooperation between India and the IEA is the strongest it has ever been. India became an Association Country of the IEA in 2017. Some examples of the IEA's work programme in India are:
  - Undertaking an In-Depth Review (IDR) of India's energy policies with NITI Aayog and all relevant Indian energy and environment ministries to be published in early 2020.
  - Working with the Ministry of Petroleum & Natural Gas on oil stocks and emergency situations in the oil market. And we have a number of current and future planned projects with the Ministry of Power, and Ministry of Environment, Forest and Climate Change.
  - Harmonising the Indian data system with NITI Aayog and 16 different data agencies in India and making it compatible with the rest of the world.
  - Working with the Bureau of Energy Efficiency on the priority area of energy efficiency including cooling, electric vehicles, and energy efficiency in buildings.

# Conclusions and the way forward (2)

- The IEA system integration team is looking forward to co-organising state level workshops with NITI Aayog and other collaborators including state level stakeholders and TERI and CER, in 2019 and 2020
  - Aim to deepen understanding of renewable integration challenges currently experienced at the state level
  - Work together with states towards a future roadmap for successful integration of high shares of renewables
- Please come and meet us if interested!

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