Beyond "baseload"

Transitioning From a Baseload System to Flexible Grids

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What is Baseload and How are we shifting away from this Concept?

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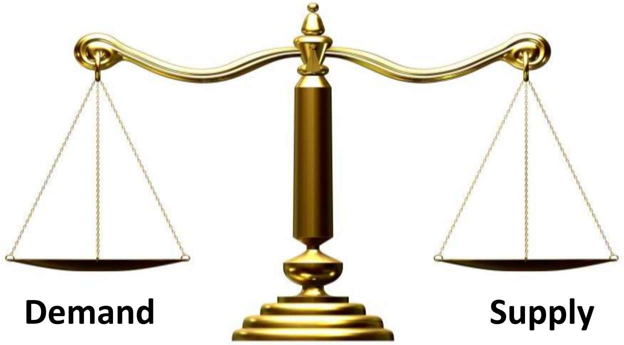
Power System Operation and Control

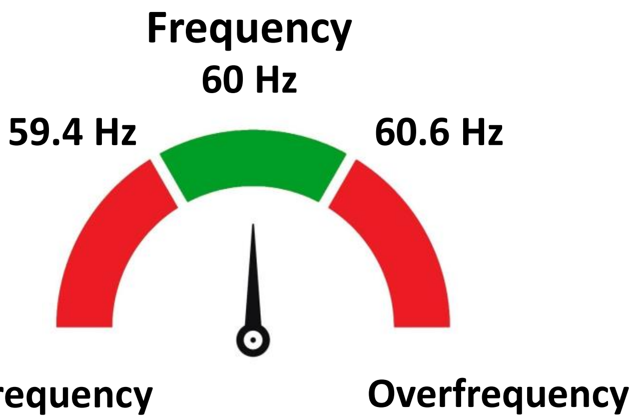
- **Power System Operations objective:**

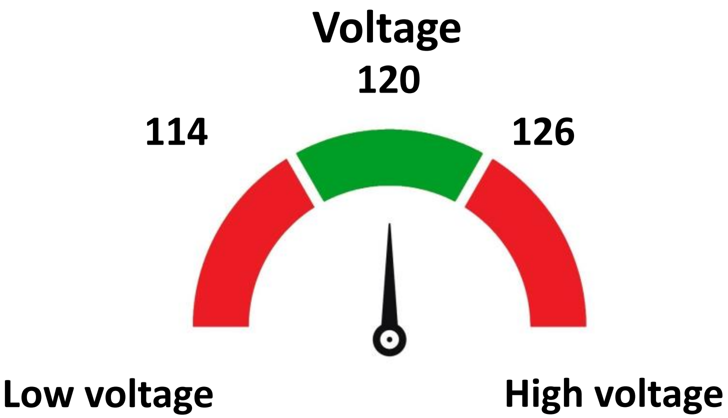
Generate and distribute power as **economically** and **reliably** as possible while maintaining the **frequency** and **voltage** within permissible limit.

Operator Responsibility:
*Maintaining the **Balance** between Supply and Demand*

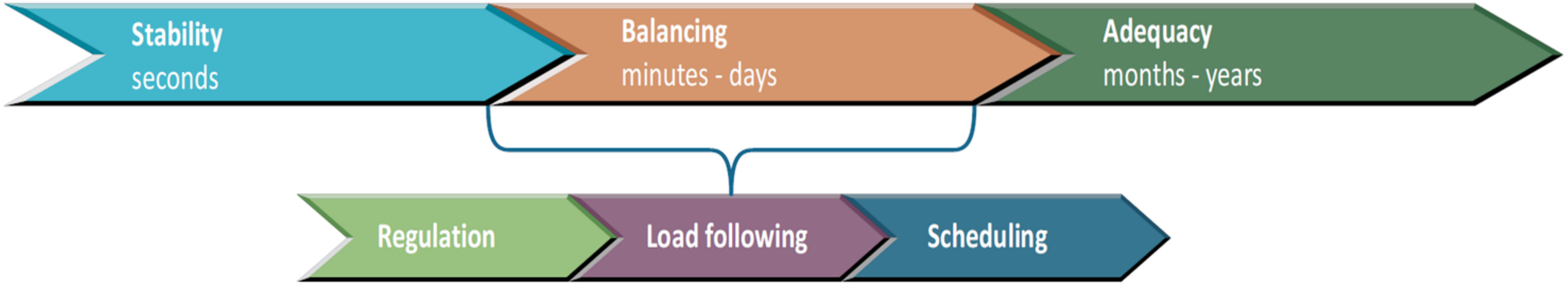


- Conventional plants provide **inertia** to the grid, a critical attribute to ensure the **system robustness** that would maintain the stability of the system **frequency**.
- They also provide **reactive power,** necessary to maintain **voltage** levels and avoid service disconnection and other equipment damages/failures.

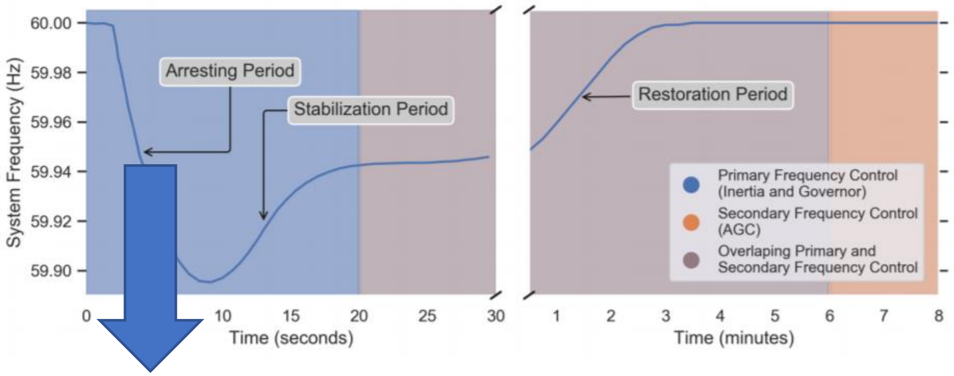




Power system balancing



	Response time	Duration
Regulation	~ 1 minute	10 minutes
Load-following	~10 to 30 minute	1 hr
Scheduling	~ 1 day	6 hrs



This essential inertia is mainly provided through baseload generation

Less system inertia results in larger frequency drops
(Rate of change of frequency – RoCoF) due to events in the system

Source: IEA, NREL

What do we mean by ‘Baseload’?

Baseload: minimum level of demand on an electrical grid over a span of time that needs to be served almost 24/7

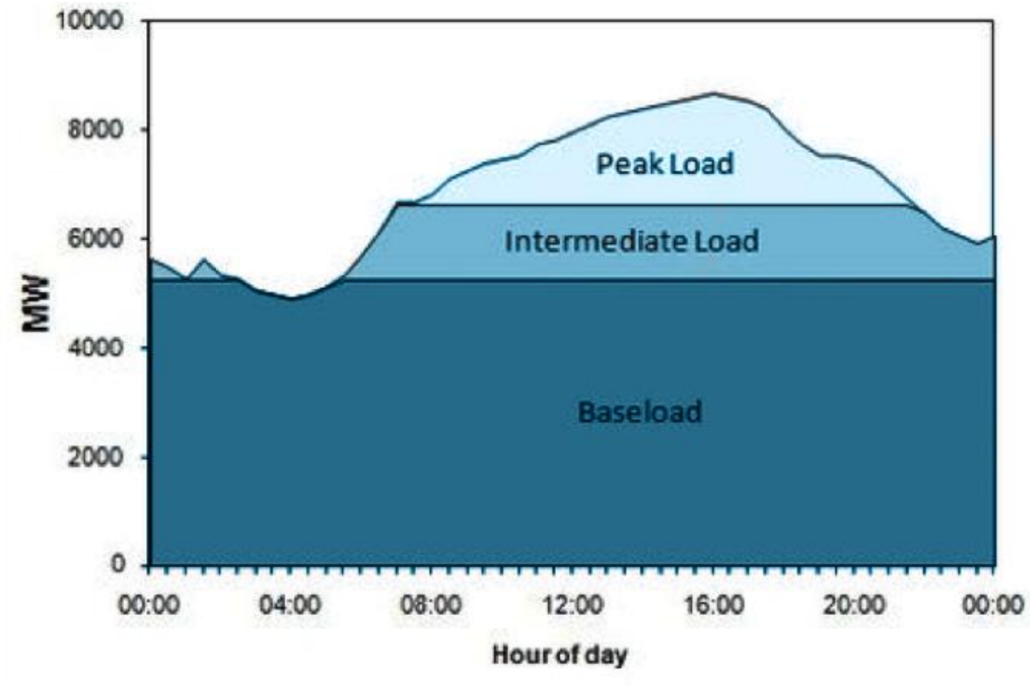
Baseload power/generation sources: the plants that operate continuously to meet the minimum level of power demand 24/7 (coal, combined cycle gas turbine, nuclear, geothermal, some hydropower plants).

Main advantages:

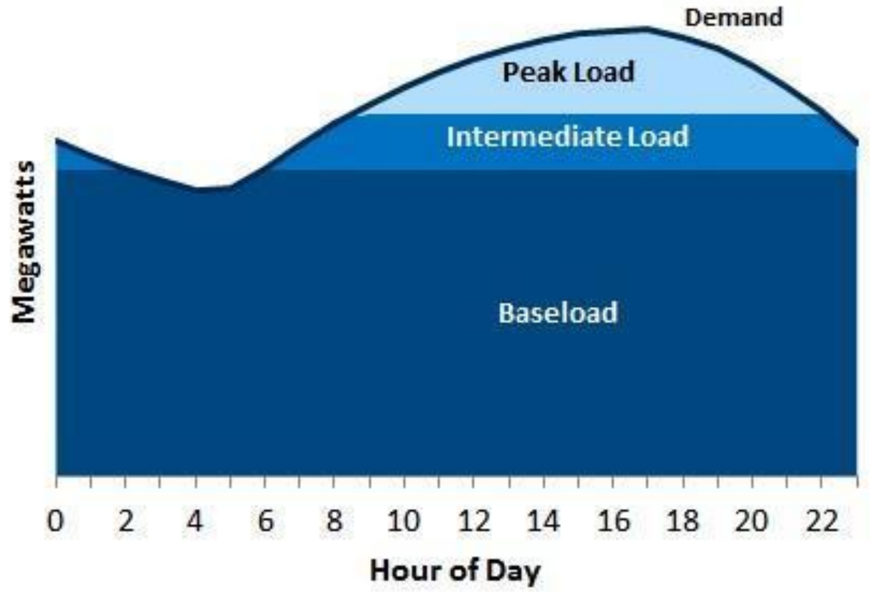
- ✓ cost efficiency (economies of scale)
- ✓ predictability
- ✓ grid services by default

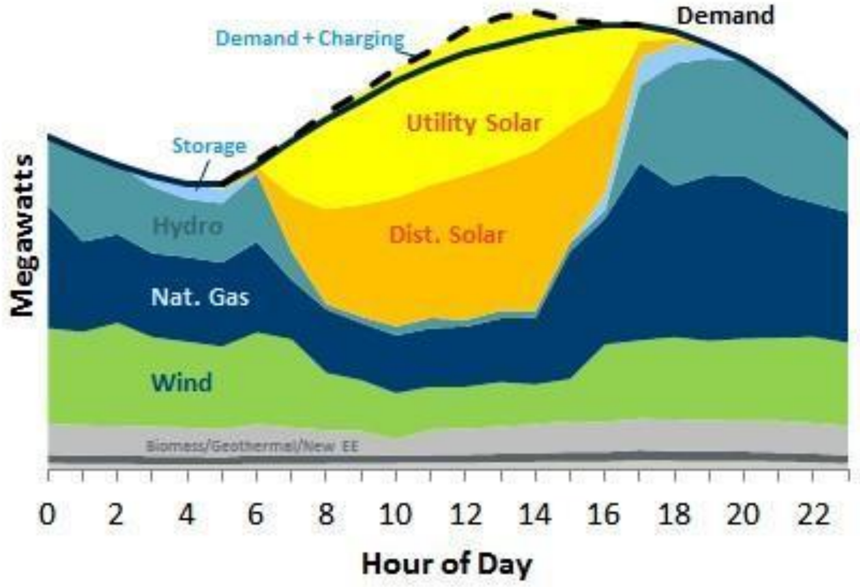
Main disadvantages:

- × lack of power output flexibility
- × low efficiency when operated below its optimal output level
- × often carbon intensive



The Baseload concept is changing due to variable sources of RE





- **Baseload generation** (e.g. coal, CCGT, Nuclear, hydro):
  - 24/7, inflexible energy + grid services
- **Peaking generation** (e.g. OCGT, hydro, combustion engine):
  - Flexible energy + some grid services

Firm power

+

Grid services

VRE generation (wind and solar) + **Flexible generation** (load following and peaking gen + storage + conventional generation with new dispatch rules)

Grid services provided through multiple sources

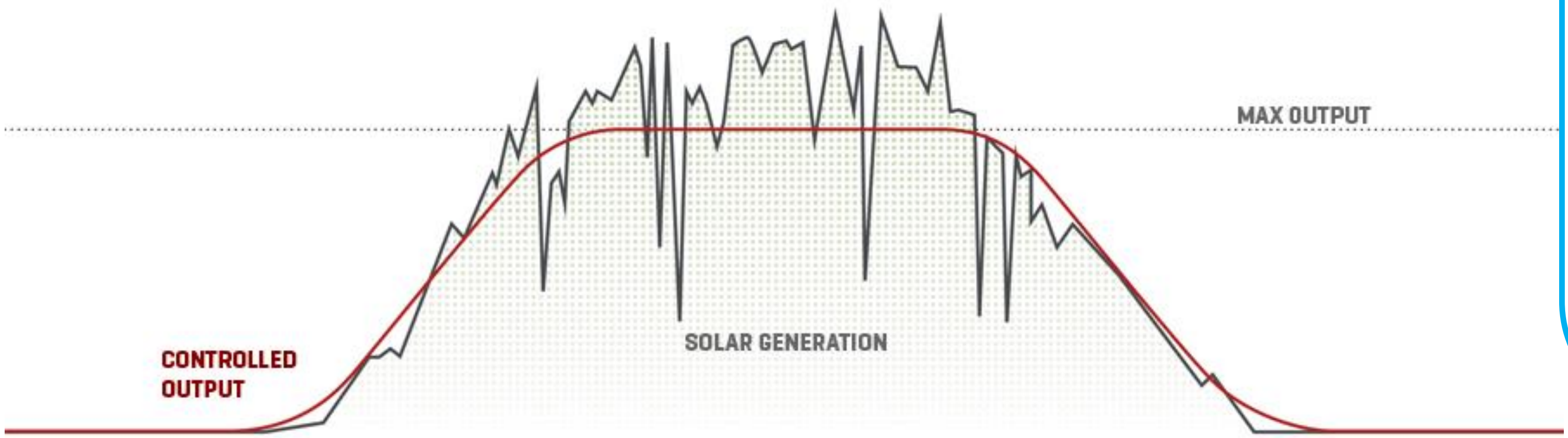
A shift from baseload to firm generation?

That will lead to an increased need of flexible options

Changing needs

- Increased **flexibility** needs to address RE variability
- Need for **system inertia** and **firm** generation

“Baseload” plants **not suited to provide flexibility** and will become costly options in this environment



How to **address this issue**?

Retrofitting generators to provide flexibility

Change of dispatch practices

New technology approaches:

- Virtual inertia provided by energy storage
- Grid functionalities through smart inverters

What is Causing this change and what are the Challenges and Solutions for developing countries?

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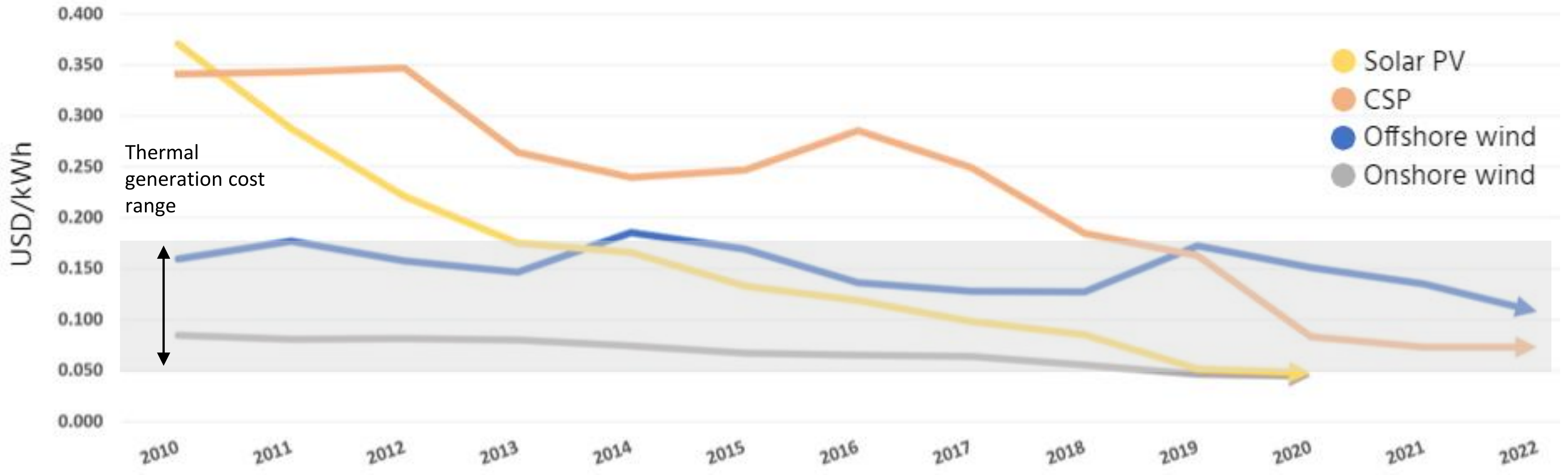
Why are countries expanding VRE?

On the supply side, changes are driven by major cost reductions in the last five years:

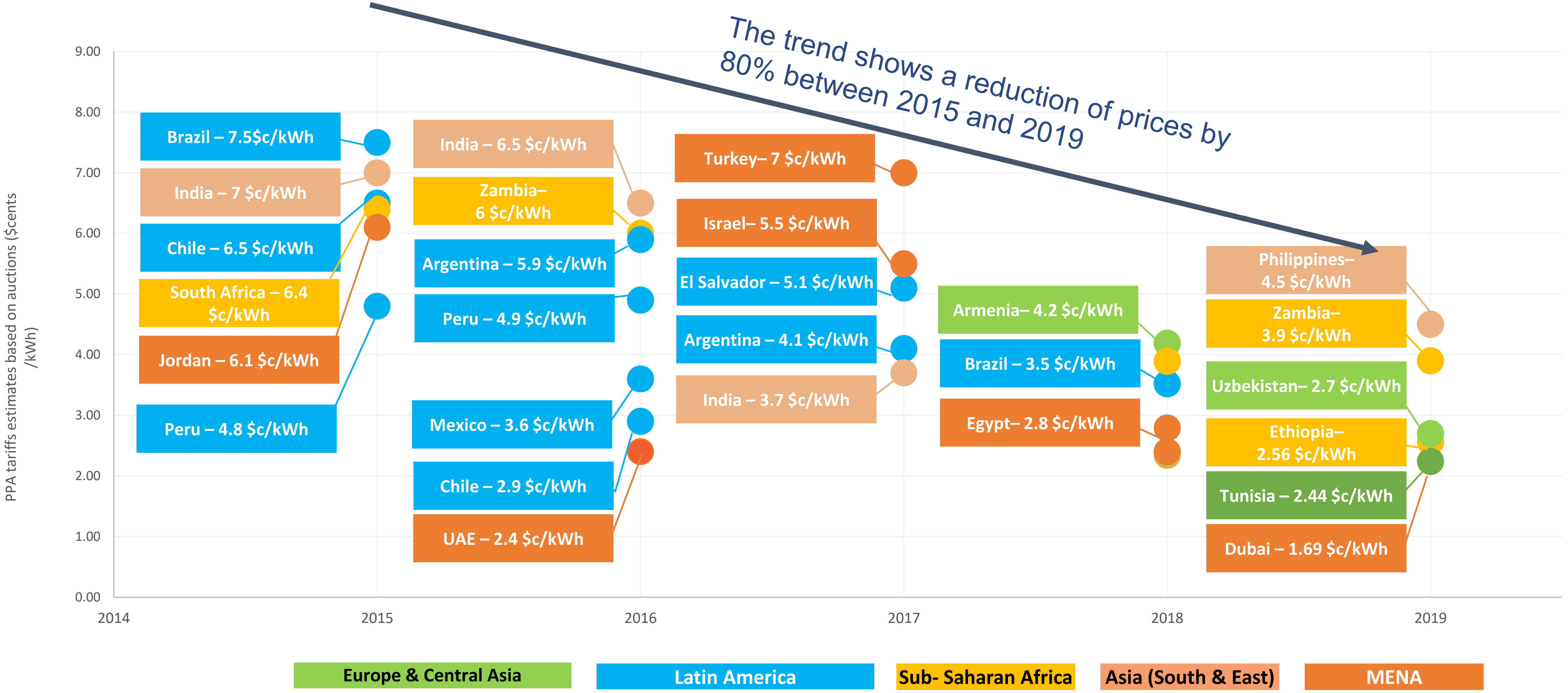
- ✓ **Increase in utility-scale VRE and storage** driven by governments and utilities
- ✓ Rapid addition of **distributed generation** (mostly solar) by businesses and households

By 2020, onshore wind and solar PV will be a less expensive source of new power than the cheapest thermal alternative BEFORE considering environmental costs



Source IRENA

Competitively tendered Solar PV projects lead to prices as low as 1.7-4.5 USDc/kWh



In comparison to PPA prices reached through competitive selection, the PPA prices in 2019 were of 10 $c/ kWh and 9.35 $c/ kWh achieved in Bangladesh through bilateral negotiations and Vietnam through feed-in tariffs, respectively.

Disruptions do not happen only on the supply side: new flexibility enablers

Grid

Digitalization increases grid flexibility and reliability

Regional integration is also an upward trend and will offer new flexibility options to newly connected systems

Demand

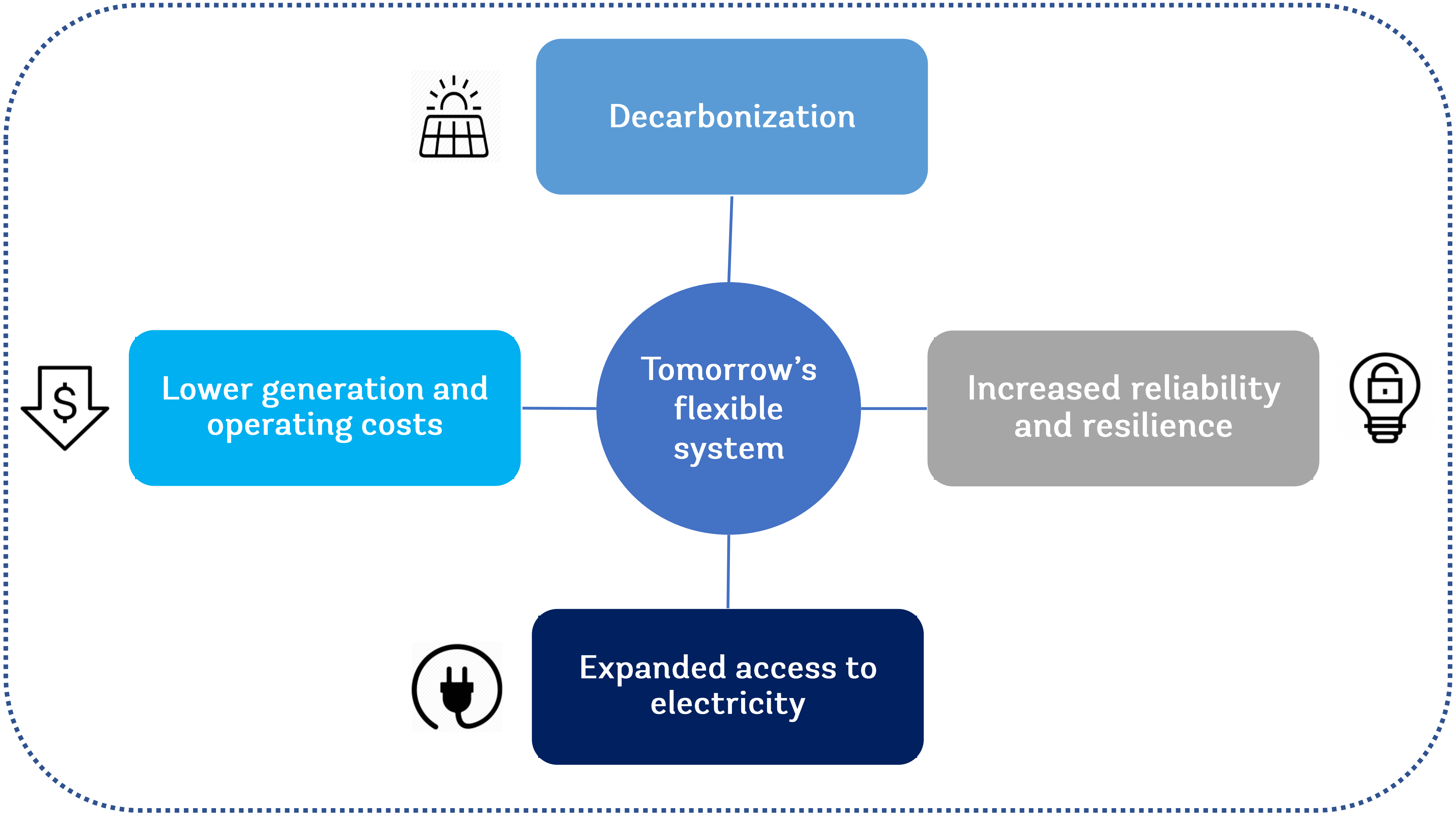
Increased load curve variability because of Electric Vehicles, self generation, new usages

As well as increased flexibility with demand response, time of use rates

Markets

Market development for both power and grid services will be another source of diversity/ flexibility

Benefits of a more flexible power system



What challenges need to be overcome to transition to the new system?

Technical Challenges

- Shortage of flexibility in the energy mix of many countries
- Lack of enabling technologies (SCADA, forecasting)
- Lack of regional interconnection
- Clustering of VRE capacity due to lack of transmission

Institutional Challenges

- Sub-optimal power system operation practices
- Need for improved regulations and grid codes to support VRE deployment increase the system flexibility
- Lack of wholesale markets and market mechanisms to incentivize flexibility

Financial Challenges

- Investment required at the system level to unlock lower cost of electricity from VRE
- Much of this falls on the public sector: transmission and grid services
- There is a clear role for climate finance to remove bottlenecks to VRE integration
- Private sector can then focus on generation projects

How to achieve flexibility?

Short Term

- Change of **operation practices** for **“conventional” baseload plants** to follow load
- **Better monitoring, control and dispatch** (flexibility, frequency and voltage control)
- **Expand the balancing area** (to import ancillary services when interconnectors exist)

Medium to Long Term

- **Smart grids** to improve **operations, predictability and speed**
- **Retrofit baseload plant** to **increase flexibility** (coal and CCGT)
- **Repurposing** retired coal plants to provide **grid services**
- Provision of **grid services/flexibility** through **various technology options** (storage, smart inverters, etc.)
- Development of **services market** and **tariff structure** to provide **firm power** and **grid services**
- **Regional integration** and **regional market development**
- **Strategic long-term planning** to define the **infrastructure investments** to support the **energy transition**

What is the WBG doing?

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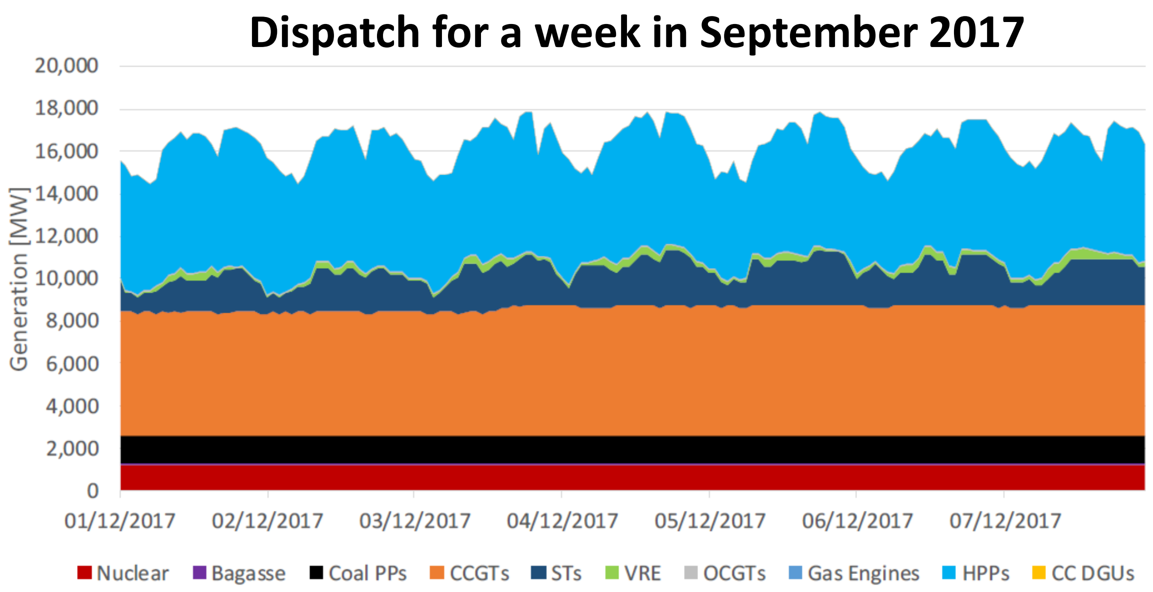
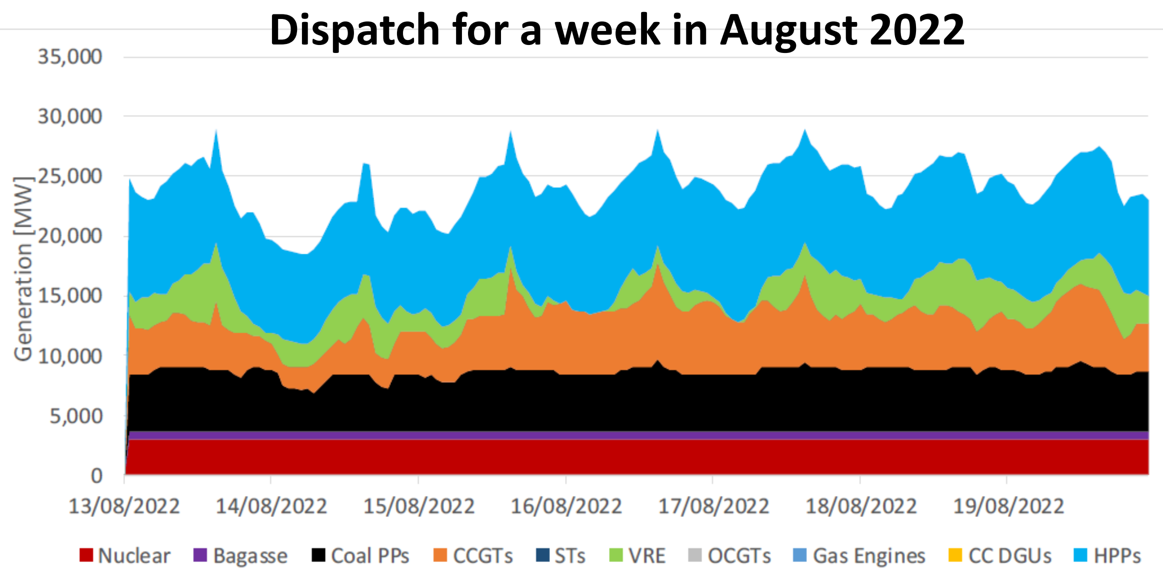
Pakistan: rapid increase in VRE has a major impact on other generators

CONTEXT
- Currently less than 5% installed VRE
- New Government targets for 20% by 2025 and 30% by 2030
- Country locked into a large amount of inflexible take-or-pay contracts for thermal

FUTURE
- Investments in grid upgrades, SCADA and forecasting essential to manage VRE
- With substantial VRE, increased need for flexibility from large hydro and thermal plants
- Additional gas and domestic coal is sub-optimal





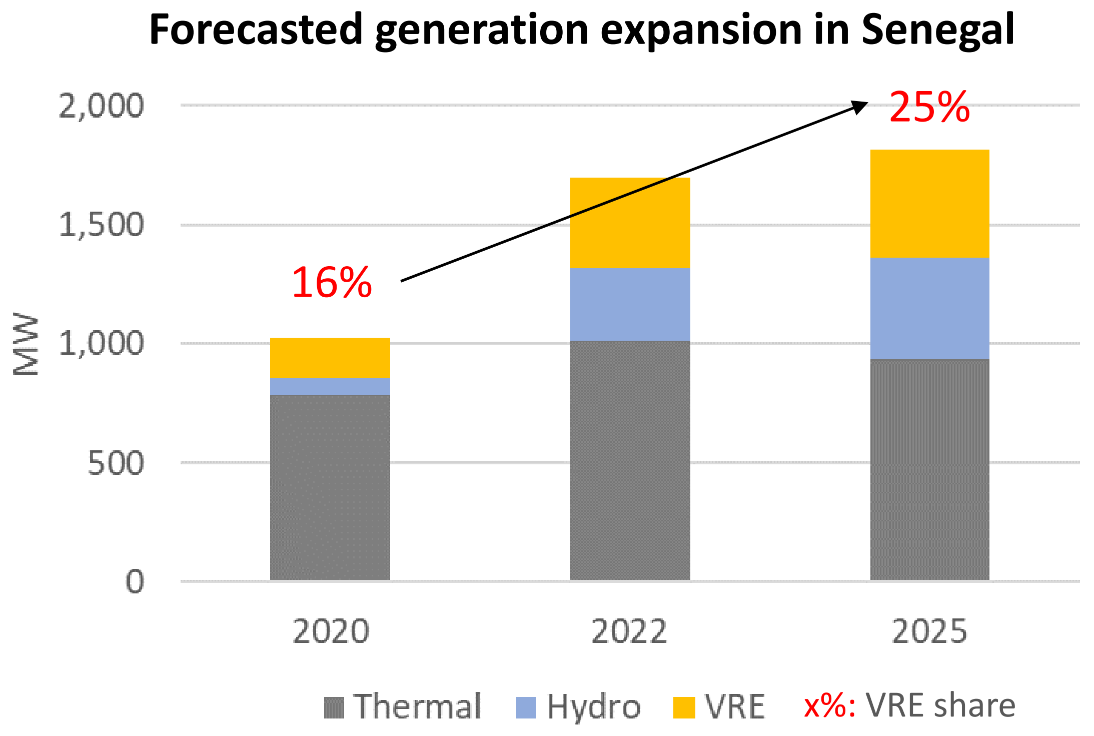
Senegal: increasing VRE through regional trade and flexible generation

CONTEXT

- Increasing share of VRE in generation mix
- A system that lacks flexibility: a few load shedding in 2017 when solar capacity reached 90MW

SOLUTIONS

- A combination of solutions including improvement in dispatch and planning capabilities and dispatch center upgrades
- Investment in flexible units and storage
- Regional integration with WAPP to access more flexibility options



Source: World Bank

This will open the door to further development of the country's vast VRE potential

How do we support our clients?

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Country Studies and Technical Assistance

- Grid integration studies
- Renewable energy geospatial planning
- Coal plant repurposing
- Development of markets for flexibility and regional markets

Global Knowledge

- Best practices on VRE integration
- Best practices for grid modernization techniques
- Energy Storage Partnership
- Green hydrogen

Operational Lending

- Regional integration and cross-border transmission
- Transmission upgrades and installation of SCADA
- Storage solutions: pumped hydro, batteries, thermal storage with renewables
- Mobilizing climate finance

SRMI: an integrated approach to support RE deployment

Combining financing from: ESMAP (Energy Sector Management Assistance Program), The World Bank (IBRD • IDA | World Bank Group), Green Climate Fund, CIF (Climate Investment Funds)

Enabling Environment

(upstream support incl. generation & transmission planning, VRE integration, regulatory and strategic support)

Critical Public Investments

(transmission lines, solar park infrastructure and PPP mini-grids/SHS)

Robust Procurement

(downstream TA support incl. transaction advisory, feasibility studies, E&S instruments)

Risk Mitigation Coverage

(guarantees for IPPs for grid-connected and off-grid projects)

Leveraging Private Investments at Scale while Maximizing Socio-Economic Benefits

QUESTIONS?