



Advancing climate-resilient
low emission development
around the world.



LEDS Global Partnership

*Advancing Climate-Resilient Low Emission Development
Around the World*

LEDS 
ENERGY WORKING GROUP

Energy Working Group

- Growing and demand driven network featuring more than 115 energy sector experts
- Brings together leading experts and practitioners around the world to support crafting of low-emissions, climate-resilient development strategies

Offering:

1. Advisory services
2. Peer learning, training, and knowledge-sharing opportunities
3. Targeted signature projects

Advisory Support

- Provided to LEDS GP participants, including Regional Platforms, Working Groups, and country-level stakeholders, policymakers, and experts.
- Covering areas of analysis, planning, finance, and implementation, as well as measurement, reporting, and verification (MRV) of climate-compatible action in the energy sector.
- Partnering with: various initiatives to deliver quick response, no cost expert assistance
 - Clean Energy Solutions Center – government policy and program and financing assistance
 - Greening the Grid and Clean Energy Grid Integration Network – RE grid integration and clean power system transformation support
 - CTCN – more in-depth clean energy technology assistance

Please inform us of opportunities for assistance

Peer learning, training, and knowledge-sharing opportunities

- Offered to practitioners tasked with planning and implementing LEDS in the energy sector
- Activities Include:
 - Development and dissemination of energy LEDS online support materials such as toolkits, advisory notes, and policy papers;
 - Design and execution of webinars;
 - Organization of energy-sector sessions and in-person workshops at global and regional LEDS events.

Please inform us of ideas for events and products that are helpful for your work.

Signature Projects

LEDS Sustainable Energy and Development World Atlas

- Documents and catalogues examples of successful low-emission and climate-compatible energy development projects around the world, including details on the programs and their observed social and economic benefits



LEDS Sustainable Energy & Development World Atlas

The Challenge

It's widely recognized that comprehensive global climate action will require massive investments in sustainable energy throughout the world, in developing and developed countries alike. Such investments have the potential to bring transformative economic, social and environmental benefits to these societies.

The international climate and development communities including public and private sector stakeholders in the developing world have a shared need to accelerate the adoption of climate-compatible energy systems in countries that are on the front lines of both emissions growth and climate impacts. Technical and quantitative data produced by and for climate and energy experts is constantly improving. However, there are few accessible and compelling resources that identify and track how sustainable energy projects have improved numerous aspects of the daily lives of millions of people around the world. Those benefits range from providing access to secure, reliable and affordable electricity services to improvements in health and gender equality, education, entrepreneurship, and economic opportunities.

The absence of well documented and communicated cases of development success stories built on sustainable energy policies and measures limits the ability to build public support, guide domestic policymaking and investment, and leverage the resources of the international community.

Our Response

In 2015, the Energy Working Group (EWG) of the Low-Emissions Development Strategies Global Partnership (LEDS-GP) plans to launch a Sustainable Energy Development World Atlas (the "Atlas") as one of its signature projects. Over the following years, the Atlas will be continuously advanced to include additional best-practice, high-impact LEDS programs which set an example for activities elsewhere.

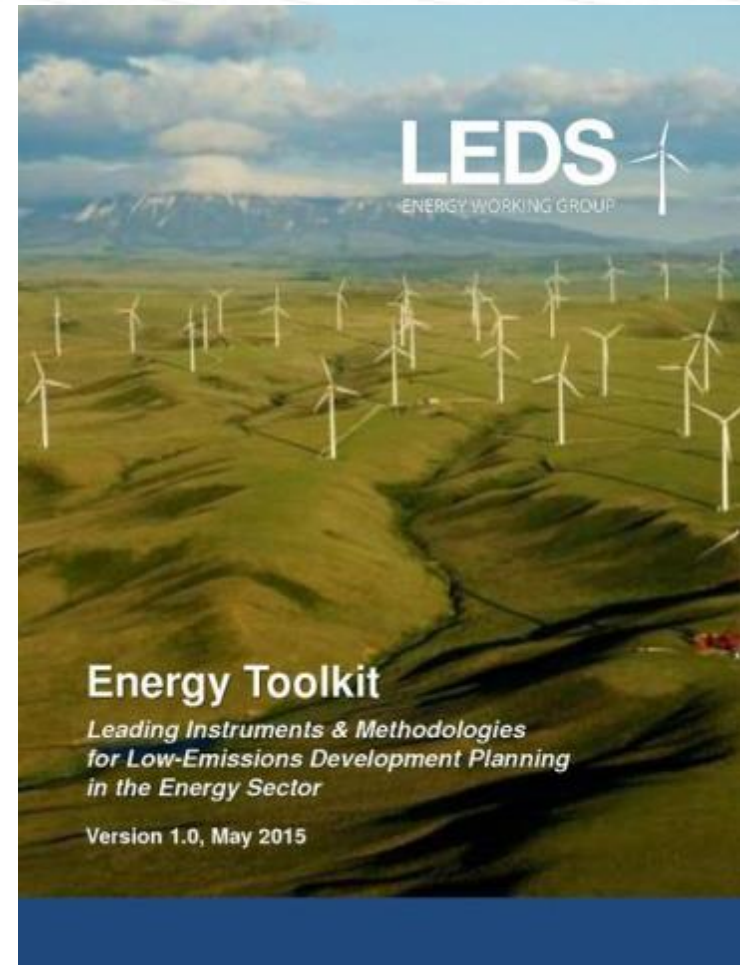
The interactive online Atlas will catalogue the development benefits (using indicators like electricity access, health, environmental quality, climate mitigation and adaptation, education, gender equality, mobility, job creation and cross-sectoral economic advancement) of representative low-emissions and climate-compatible energy projects. Projects will include those relating to power generation, consumption, transmission, distribution, heating & cooling, and transportation – throughout Africa, Asia, Eastern Europe, and Latin America & the Caribbean.

The Atlas will become a powerful tool in presenting successful energy LEDS and their societal impacts to anyone interested in the topic, both experts and non-experts. It will provide the LEDS-GP network with a central forum for the exchange of knowledge. And it will help individual governments, project developers, implementing agencies, funders and other key actors understand and communicate the full value of sustainable energy deployment.

Signature Projects

Energy Toolkit

- Collection of leading instruments and methodologies for low-emission, climate resilient development planning in the energy sector



Signature Projects

Communities of Practice (CoP)

- Demand driven and dynamic channels for communication between individuals in the energy sector for peer-to-peer learning.
- Interactive online sessions and in-person workshops to discuss challenges and solutions related to specific policy topics

EWG Contact Information

EWG Chair: Alexander Ochs,
aochs@worldwatch.org

Caribbean Program Manager: Kevin De Cuba,
Kdecuba@worldwatch.org

EWG Manager: Philip Killeen,
pkilleen@worldwatch.org





Advancing climate-resilient
low emission development
around the world



LEDS Global Partnership

*Advancing Climate-Resilient Low Emission Development
Around the World*

Renewable Energy Grid Integration

LEDS GP Energy Working Group Session
Annual Event - October 2015

Power sector transformation definition

Power system transformation is the active process of creating the policy environments, and the planning and operating practices, that accelerate investment and innovation in power systems that maximize the use of sustainable energy and maximize delivered energy productivity, while also fostering the integration of power systems with transportation, heating and cooling, and broader resource management.

A complex, dynamic process - not an end-goal

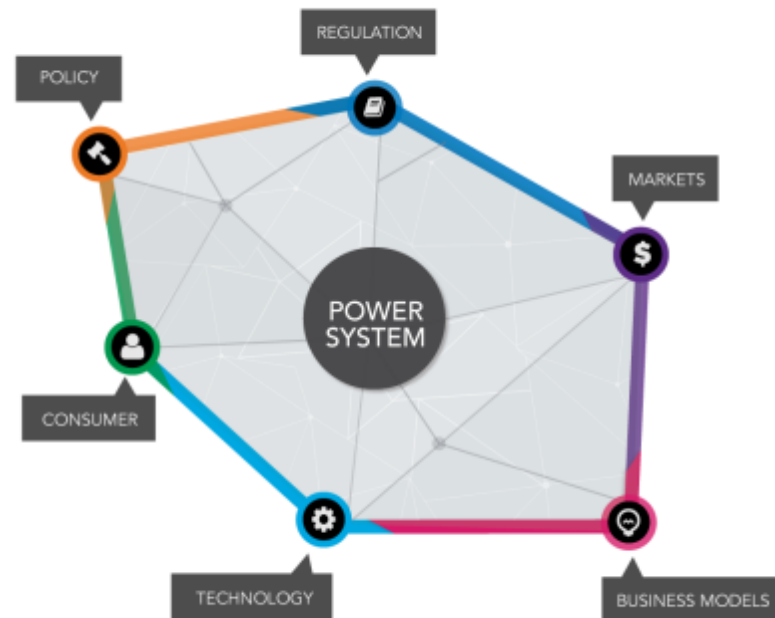
Taking place at different rates and in different forms around the world

Multiple drivers and policy rationales

(e.g. technological innovation, energy access, social change, environmental and public health concerns, customer preferences, national fiscal and energy security strategies)

Multiple enablers

(e.g. financial & business model innovation, policy and regulatory frameworks, improved grid sensors and controls, declining technology costs)

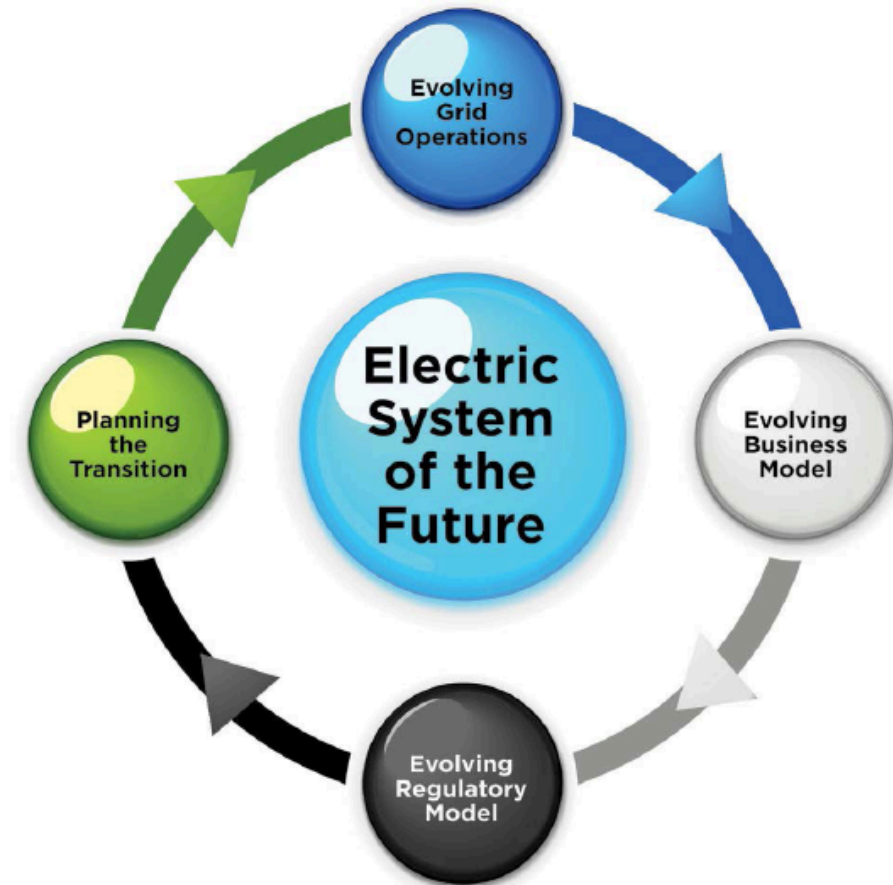


Evolution of the power sector

How countries **envision**, **plan**, and **regulate** the power system is evolving.

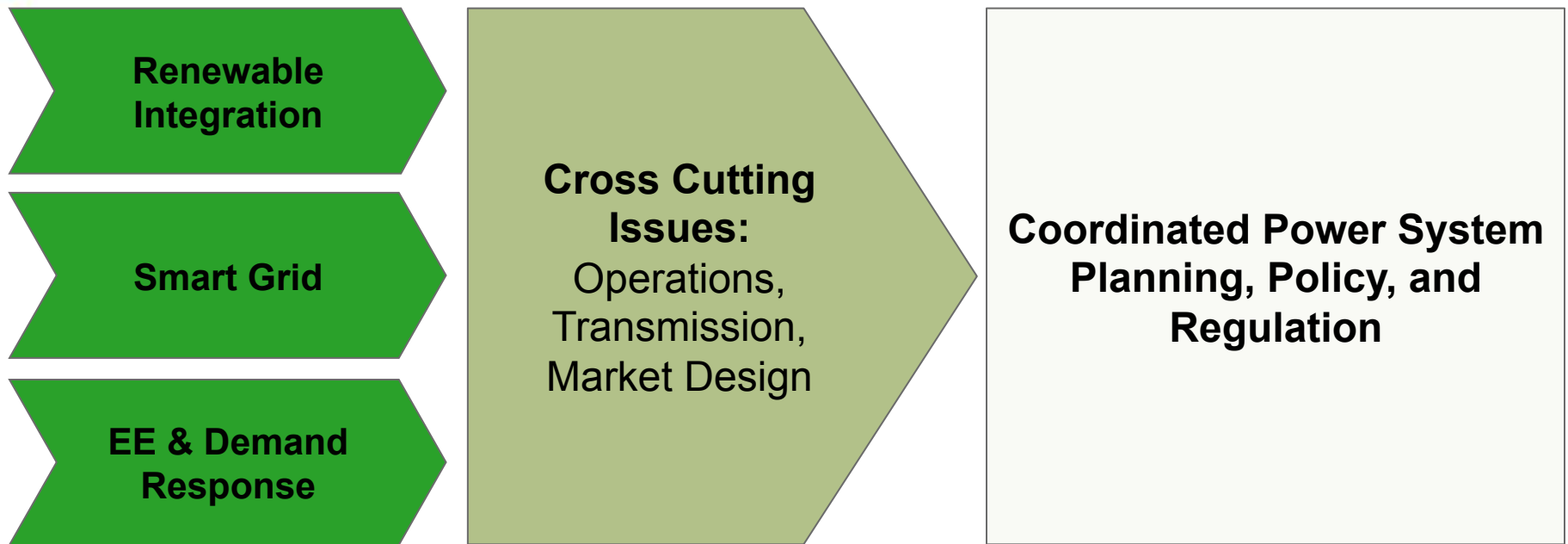
Long-held beliefs are evolving:

- Renewables are now a cost-effective resource in many locations and have been proven not to require 1-to-1 reserves.
- Distributed generation is not tantamount to the “utility death spiral.”
- Planning, operational, and regulatory strategies must evolve but do not necessarily cost more to implement.
- Networks can be cost-effectively expanded from the bottom up.
- Utilities can sell more than just electrons.



Source: GridWise Alliance, U.S. Department of Energy

Scope of power sector transformation



Why is RE grid integration an important topic?

Trends:

Increasing energy demand

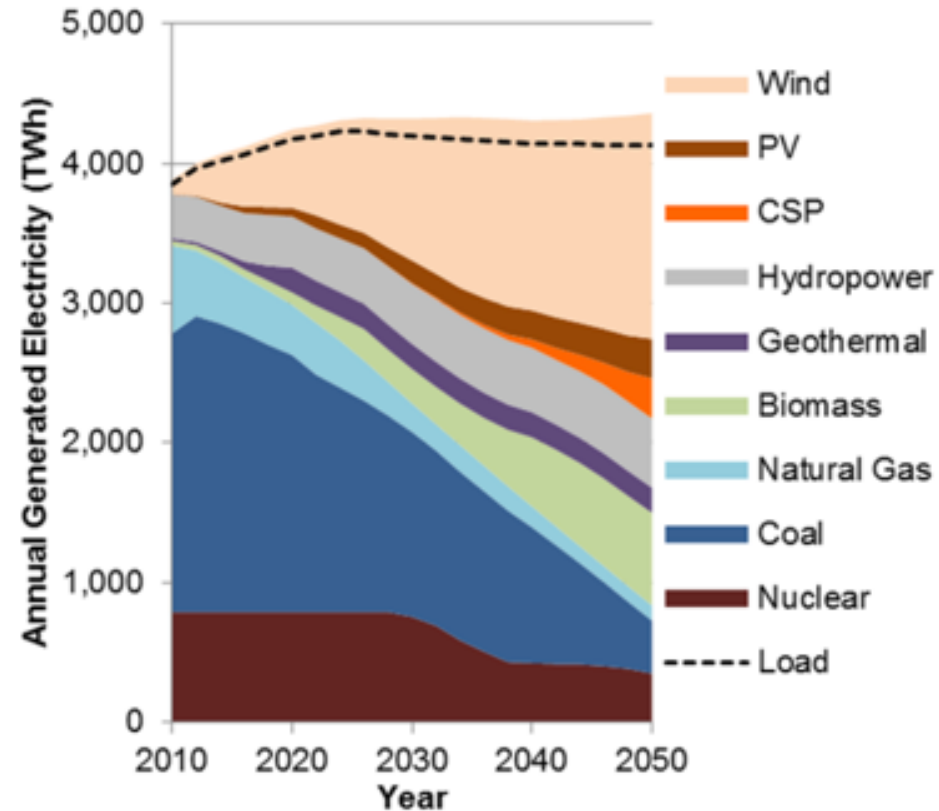
Urbanization

Climate change mitigation targets

Need for grid modernization

Every power system has characteristics that promote and inhibit integration of variable RE

Grid integration is the practice of developing efficient ways to deliver high penetration levels of variable RE to the grid



Source:
"Renewable Energy
Futures" 2012

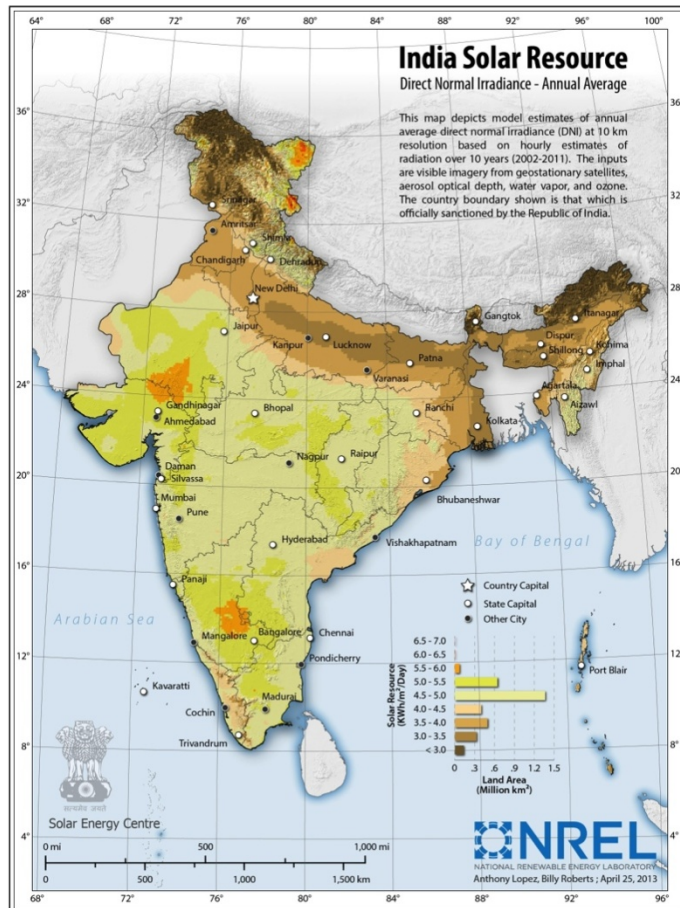


greening the grid



Evolving power system planning to support RE grid integration

RE is variable, uncertain, and geographically dispersed



...raising new considerations for grid planning and operations

- 1. Balancing requires more flexibility**
- 2. Existing thermal assets used less frequently, affecting cost recovery**
- 3. More reserves**
- 4. More transmission, better planning needed**
- 5. Voltage control, inertia response come at added cost**

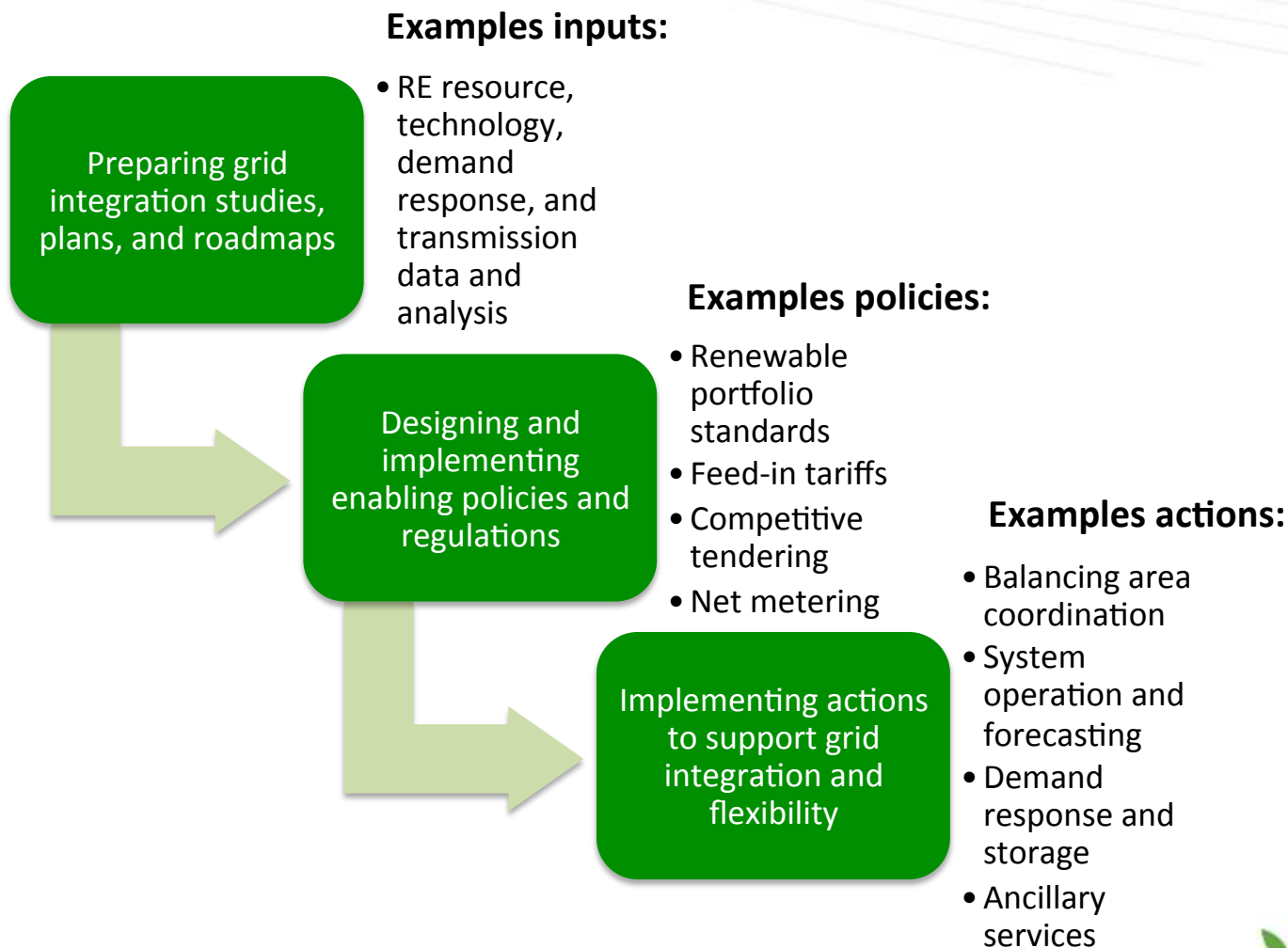


greening the grid



Advancing energy solutions
for a sustainable world

Key steps to support RE grid integration



Focus area: Grid integration studies as a starting point

| Analysis/Data type | Capacity value calculations | Unit commitment and dispatch simulations | Load flow analyses | System stability studies |
|---|--|--|--------------------|--------------------------|
| VRE resource | ✓ | ✓ | ✓ | ✓ |
| Load | ✓ | ✓ | ✓ | ✓ |
| Forecast & forecast errors | | ✓ | | |
| VRE equipment characteristics | ✓ | ✓ | ✓ | ✓ |
| Conventional fleet characteristics | ✓ [Capacity and forced outage rates] | ✓ | ✓ | ✓ |
| Demand response & storage characteristics | ✓ [If operational practices are known] | ✓ | ✓ | ✓ |
| Transmission grid | ✓ | ✓ | ✓ | ✓ |

Table 1. Common grid integration analyses and their data requirements. (Adapted from [2])



Grid integration studies require a variety of inputs, including data on renewable resource



Focus area: Power system regulation to provide a strong enabling environment

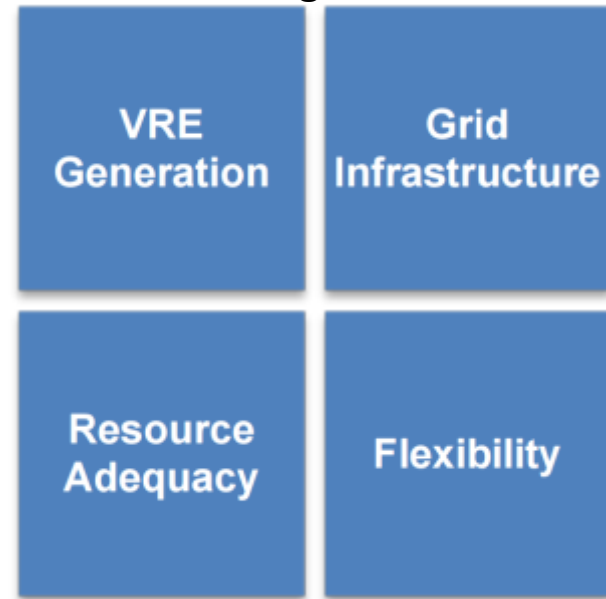
Existing Objectives



Emerging Objectives



4 Main Categories of VRE Regulation

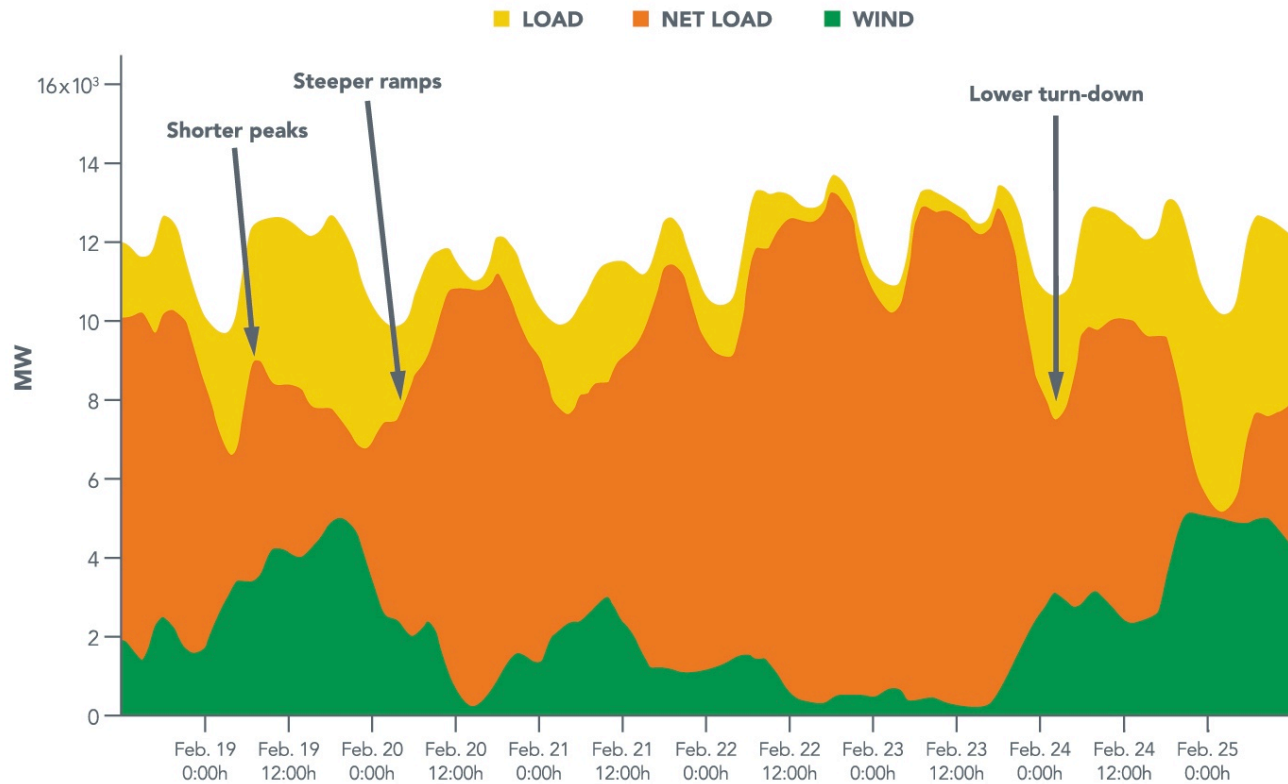


Source: Evolving Role of the Power Sector Regulator: A Clean Energy Regulators Initiative Report.
<http://www.nrel.gov/docs/fy14osti/61570.pdf>

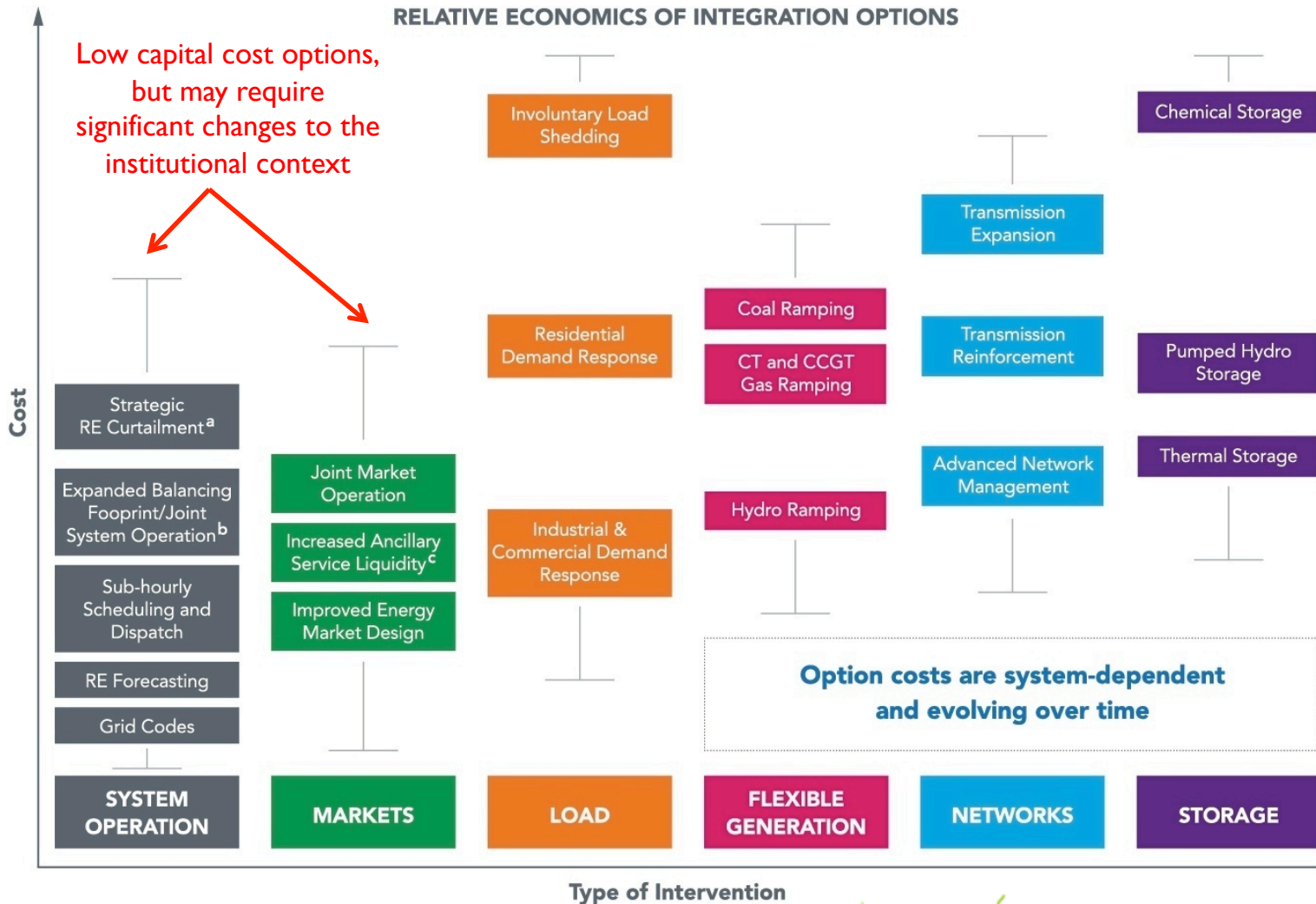
Source: Overview of Variable Renewable Energy Regulatory Issues: A Clean Energy Regulators Initiative Report
<http://www.nrel.gov/docs/fy14osti/61350.pdf>

Focus area: Flexibility to address grid integration challenges

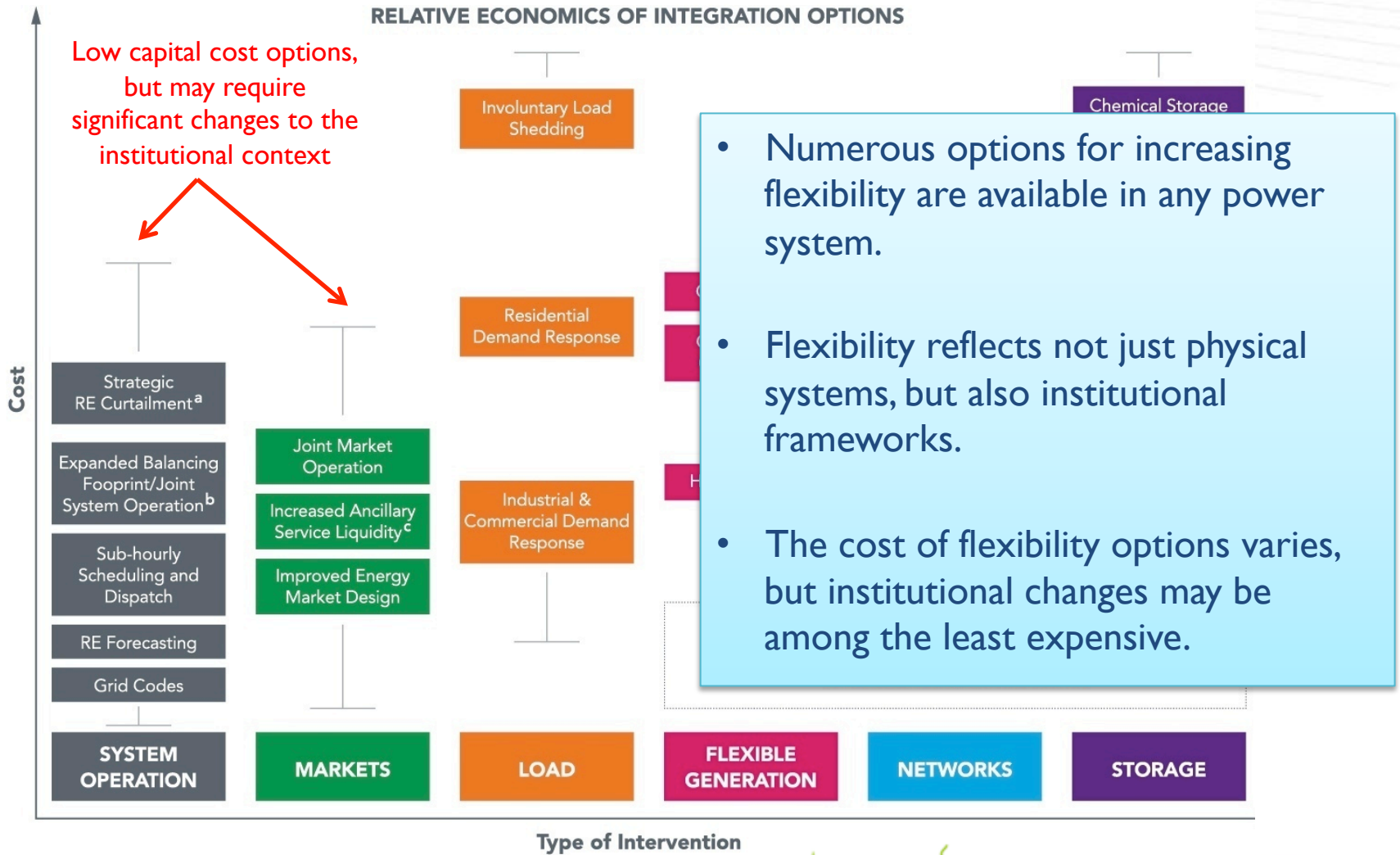
Flexibility: The ability of a power system to respond to change in demand and supply



Frequently used options to increase flexibility



Frequently used options to increase flexibility



Supporting grid integration solutions

LEDS GP Energy Working Group (EWG)

The EWG promotes low-emission and climate-resilient development in the energy sector through a work program focused on learning and information exchange, sharing best practices, advisory services, and providing enhanced opportunities for coordination and collaboration.

Objectives

- **Strengthen support** for LEDS in energy sector
- **Mobilize capacity and advance peer-to-peer learning and collaboration** on low emission energy development
- **Improve coordination** of energy-related LEDS at the country, regional, and global levels

Energy Working Group and Regional Platform Support for RE Grid Integration

- Collaboration with Power Sector Transformation Initiatives
 - Clean Energy Grid Integration Network / Asia Network – LEDS GP a key partner
 - Greening the Grid
 - 21st Century Power Partnership
 - World Bank ESMAP Variable RE Generation Initiative, IRENA, and others
- Delivering Training
 - 1 day training at Asia Clean Energy Forum in June
 - Additional regulators in IRENA training on grid integration in Tanzania in Oct.
- Expert Assistance
 - Advice & assistance to countries on grid integration policies and measures
- Technical Resources
 - Case studies and sharing reports from others – GTG, 21CPP, IRENA, IEA, etc.
- Exploring Potential Exchange Programs (Asia Network, partner with 21CPP)

Clean Energy Grid Integration Network

www.cleanenergysolutions.org/cegin

Objective: Help strengthen **policies and programs** to enable high levels of renewable energy generation for electricity systems, along with related demand response, smart grid, and storage solutions.

Partners:

- Clean Energy Solutions Center
- 21st Century Power Partnership
- US Agency for International Development (USAID)
- LEDS GP Energy Working Group
- Asia Low Emission Development Strategies Partnership (ALP)
- Greening the Grid Toolkit team

CEGIN resources and services

- **Expert Technical Assistance** - Customized expert technical assistance from the Clean Energy Solutions Center and other technical institutions.
- **Training and Knowledge Exchange** - Web-based seminars, training workshops and other peer-to-peer learning forums to facilitate the sharing of good practices and capacity building and enable direct exchange of experiences across countries.
- **Technical Resources on Good Practices** - Provides a curated library of the most relevant reports, data and tools to help accelerate clean energy grid integration policy design.
- **Regional and Global Networks** - CEGIN is establishing a network of Asian country officials (regulators, system operators, and energy planners) who are developing clean energy grid integration policies and programs to share good practices and solutions for grid integration. CEGIN is exploring opportunities to create similar networks in other regions.

Table discussion

- Structure:
 - This group exercise will bring together 2-3 countries at each table for interactive discussion (60 minutes)
- Specific discussion questions to consider:
 - What challenges related to RE grid integration is your country or jurisdiction facing?
 - What solutions or approaches can you share with the group to address these challenges?
 - How can the EWG support your efforts?

Additional resources and networks to support power sector transformation

Clean Energy Solutions Center

<https://CleanEnergySolutions.org>

Launched in April 2011

- One of 13 Clean Energy Ministerial Initiatives
- Led by U.S. Department of Energy, Australia Department of Industry, International Copper Association, and engages more than 35 partners
- Delivers services to all developing and developed countries

Ask-an-Expert

- Technical assistance from > 40 global experts on clean energy policy topics – responding to over 160 requests to date

Training/Peer-to-Peer Learning

- Webinars, videos and other resources –reaching more than 6000

Resources

- Over 2100 reports, data, and analysis tools related to clean energy policy & emerging policy studies

Greening the Grid



Offers a **toolkit** of information and guidance materials to inform the development and implementation of grid integration roadmaps



Facilitates direct **technical assistance** tailored to the unique power system characteristics and priorities of each partner country

Greening the Grid is a component of the U.S. Government's Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) program



greening the grid



Advancing climate action
on a mission. Sustainable
around the world.

Greening the Grid Toolkit

The screenshot shows the homepage of the Greening the Grid Toolkit website. At the top, there is a search bar and a 'Log In' button. Below the search bar is a navigation menu with links for HOME, OVERVIEW, TRAININGS, INTEGRATION TOPICS, ASK AN EXPERT, GLOSSARY, and RESOURCES. The main content area features a large banner image of a solar farm with a dark overlay box containing the text 'Understand Grid Integration Basics' and a link to 'Read more'. Below the banner, there are three main content boxes: 'What is Grid Integration?' with an icon of power lines and a 'Read more' button; 'What We Do' with an icon of a gear and a 'Read more' button; and 'Ask an Expert' with an icon of a speech bubble and a 'Submit a Request' button.

greeningthegrid.org



greening the grid



21ST CENTURY POWER PARTNERSHIP

Country-level Programs

21CPP teams with key stakeholders in **India**, **Mexico**, and **South Africa** to support power system transformation activities. Stakeholders may include:

- Government agencies
- Regulators
- System operators
- Technical institutes
- National utility and transmission companies

In-country activities are guided by priorities set by the national governments. These activities may include:

- Assistance with national and regional power sector modeling and roadmaps
- Strengthening of regulations and enabling policies
- Improved forecasting and control strategies for more effective RE grid integration

21ST CENTURY POWER PARTNERSHIP

Knowledge Development and Sharing

21CPP coordinates targeted knowledge development and dissemination efforts. This includes reviewing, researching and developing case studies of timely, policy-relevant electricity sector issues such as:

- Regulatory frameworks to expand **energy efficiency and smarter grids**
- Opportunities and challenges among evolving **utility business models**
- Methodologies for guiding **integration planning**

Accelerates dissemination of knowledge through multiple channels, including workshops, **web forums, thought leadership reports, & information databases**



21ST CENTURY POWER PARTNERSHIP

Organizing Global Networks of Expertise

The Partnership organizes platforms for multilateral expert consultation, which have included:

- Grid operator workshops
- Multi-stakeholder regulatory exchanges
- Public-private roundtable discussions
- Fellowships to support cross-national short-term assignments in peer institutions.



RENEWABLE ENERGY GRID INTEGRATION PRACTISES IN INDIA

BY

PRADEEP KUMAR DADHICH, PHD

Integrated Research and Action for Development (IRADe), New Delhi

PRESENTED AT THE LEDS GLOBAL PARTNERSHIPS

VENUE: PUNTA CANA

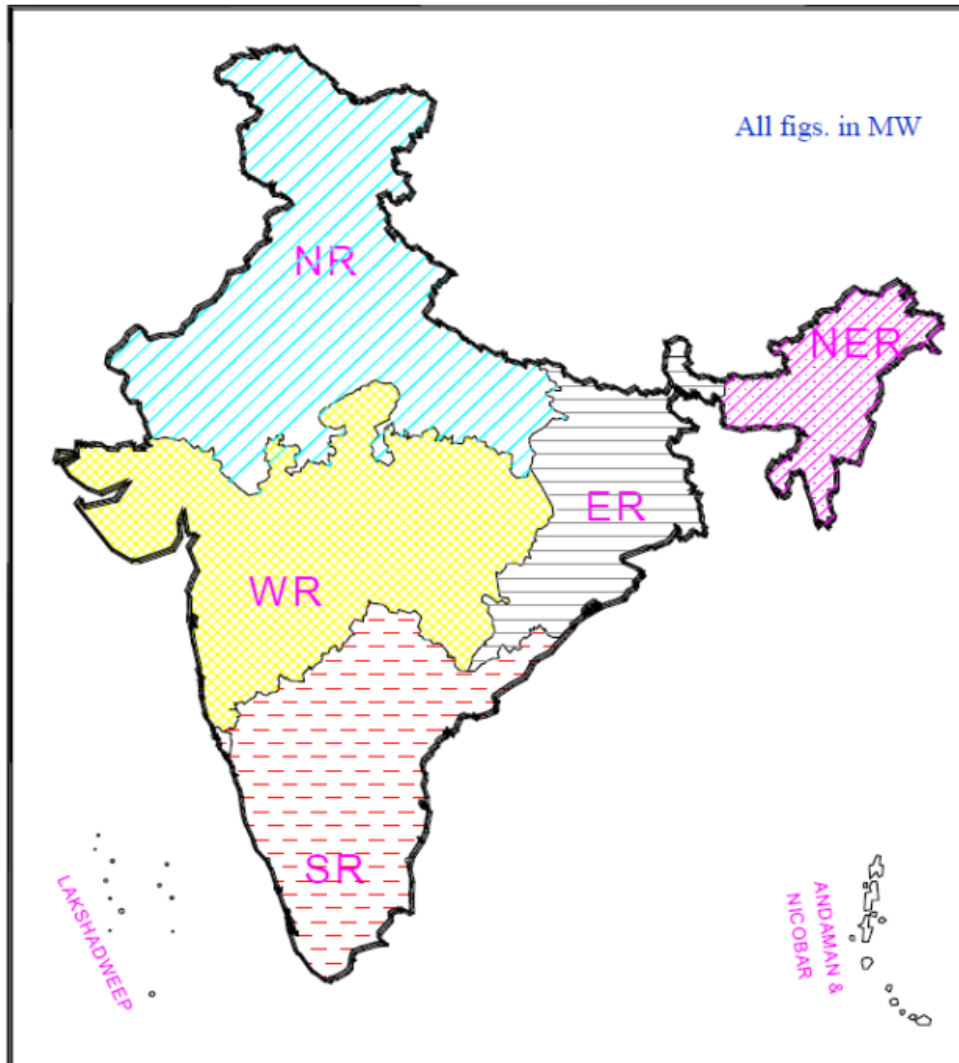
14 – 16TH OCTOBER 2015

Contents

- ▶ India's Power Status & RE Challenge
- ▶ Issues in Grid Integration of RE
- ▶ Actual examples of RE variability
- ▶ Mitigation measures for RE integration with grid
- ▶ India's transmission network and inter-regional power transfer infrastructure
- ▶ Status of various measures to enhance grid integration of RE



India's Power Status



**Installed Capacity –
232,000 MW**

- Thermal- 60%
- Hydro- 17%
- Nuclear- 2%
- Renewable- 12%

**Peak Demand –
135,000 MW**

**Per capita
consumption– 880 kwh**

Indian Challenge

▶ Renewable Energy Targets:

- ▶ From current capacity of 27 GW to 175 GW by 2022
- ▶ 100 GW Solar – 40 GW of grid connected rooftop and 60 GW large and medium solar projects
- ▶ 60 GW Wind & 15 GW Small hydro and Biomass

Renewable energy installed capacity is expected to be 55% of the demand 295 GW.

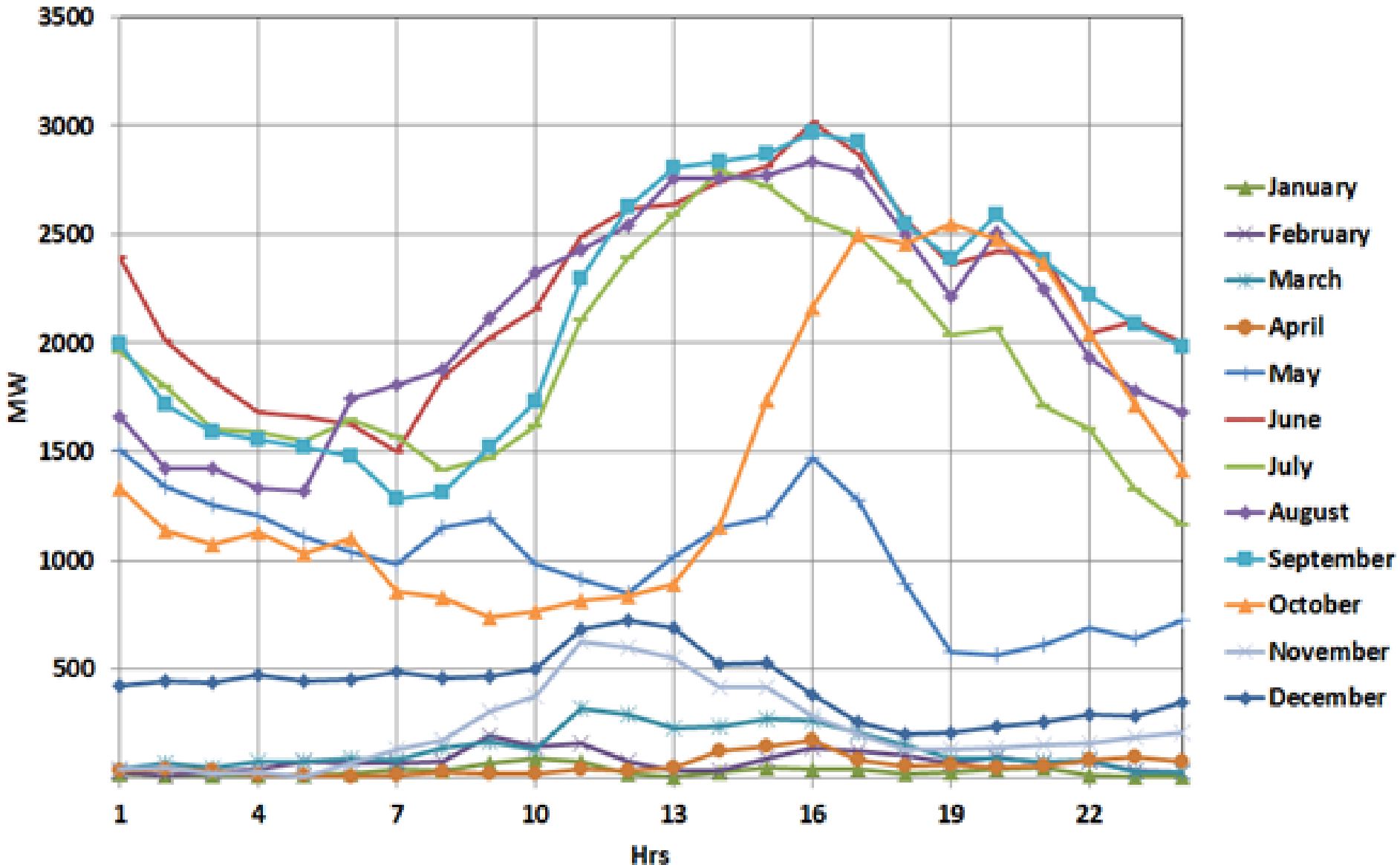


Grid Integration of RE Challenges

- ▶ Intermittency and variability impacting grid stability
- ▶ Implementation of transmission network matching RE generation
- ▶ Technical issues like reactive power management etc. Real Time Grid Operation
- ▶ Economic viability of transmission system low due to poor capacity utilization factors (20% to 30%).

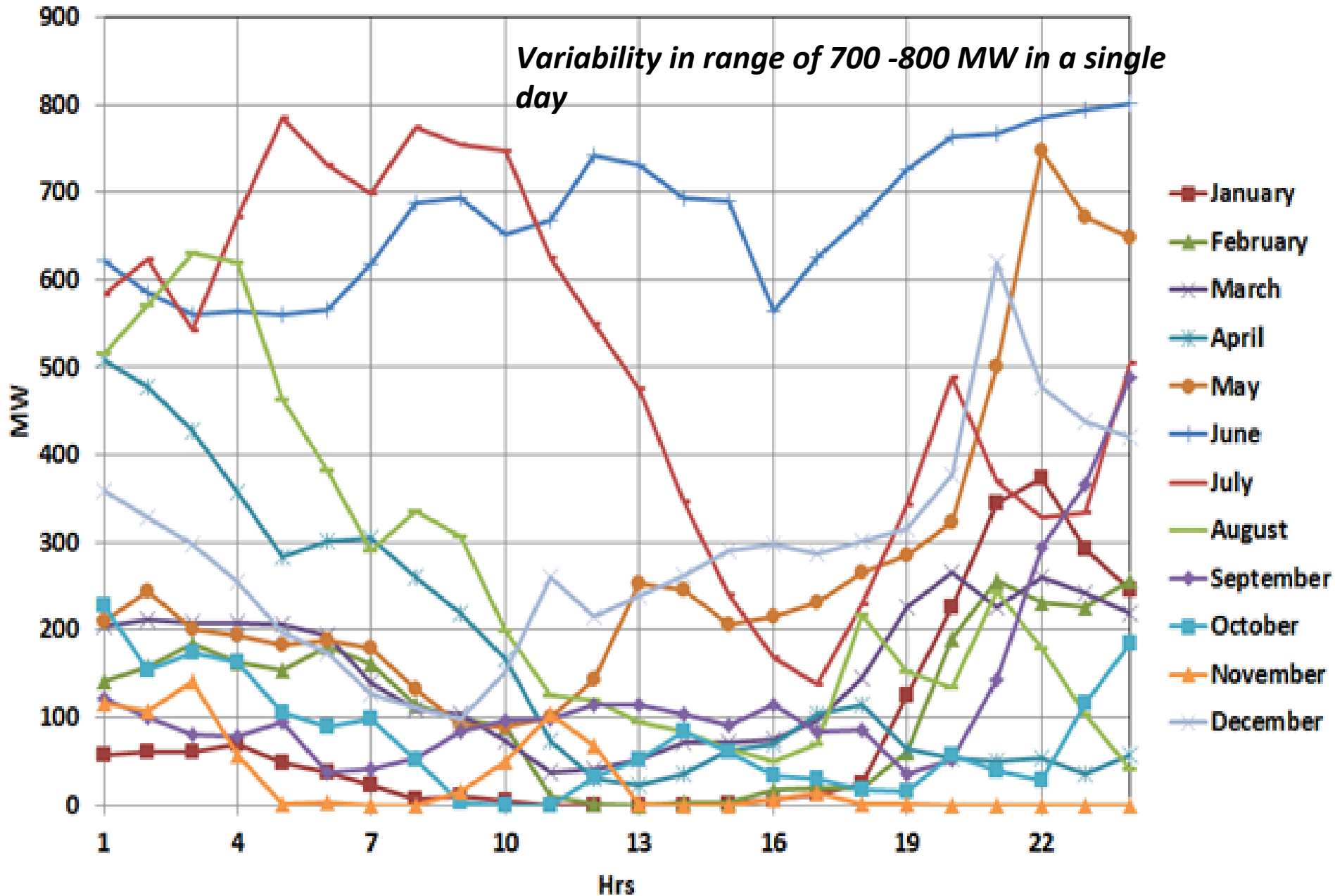


Tamil Nadu Typical Daily Wind Generation Pattern Month wise

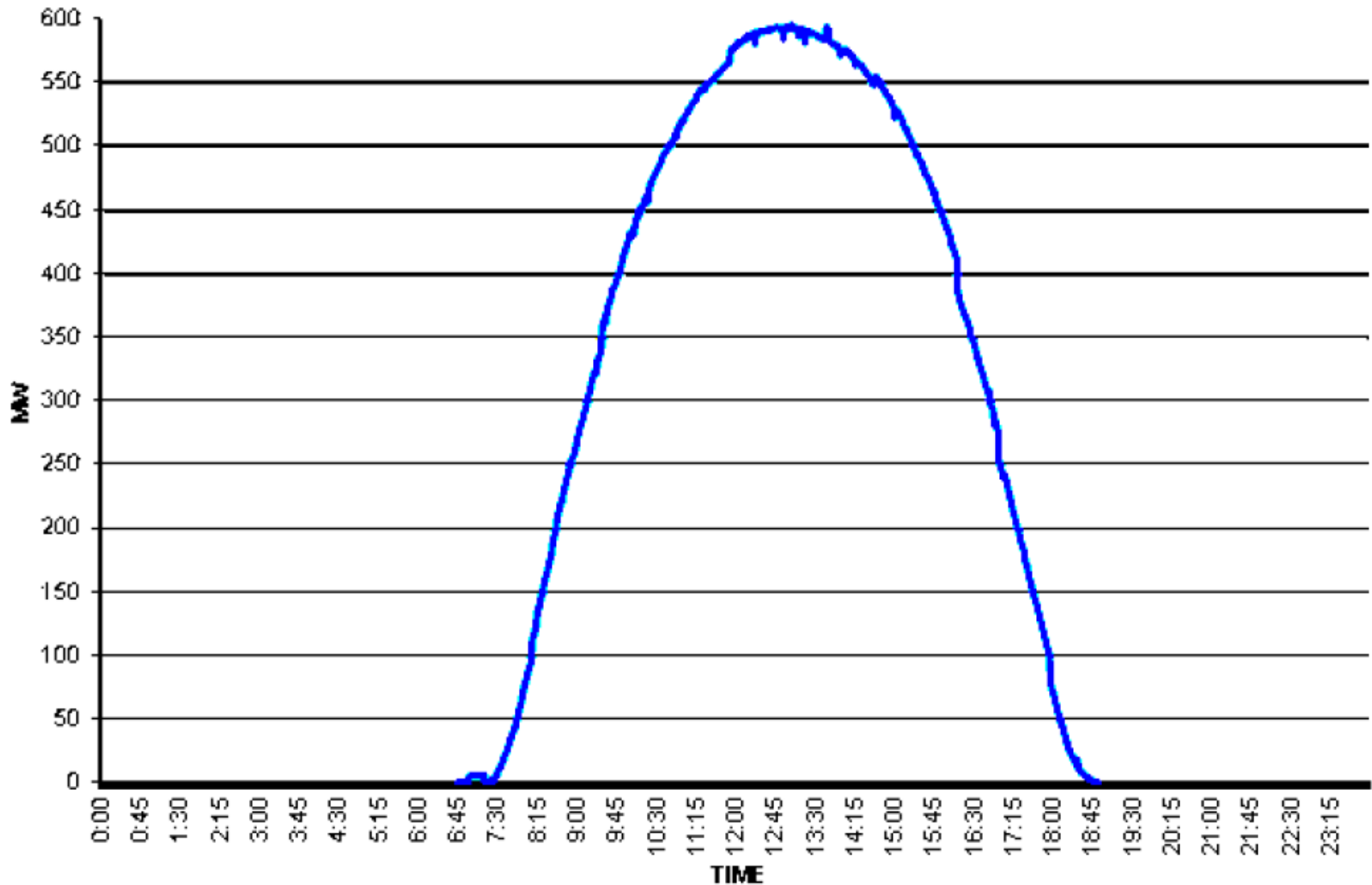


▶ **Variability in range of 1500 -1800 MW in a single day**

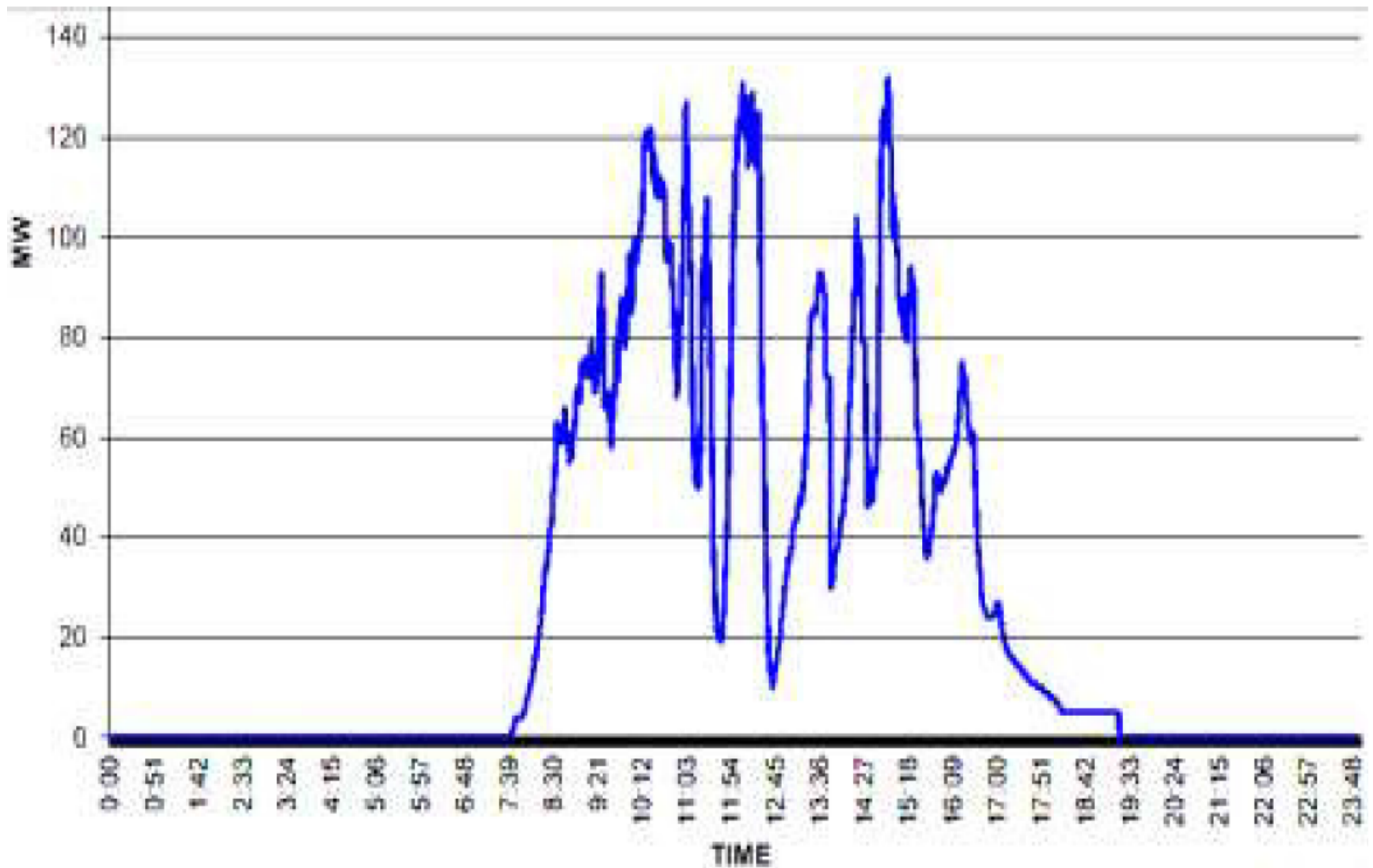
Rajasthan Typical Daily Wind Generation Pattern Month wise



Solar Energy Generation in Gujarat in Charanka Solar Park on a Normal Sunny day



Solar Energy Generation in Gujarat in Charanka Solar Park on a Cloudy Day

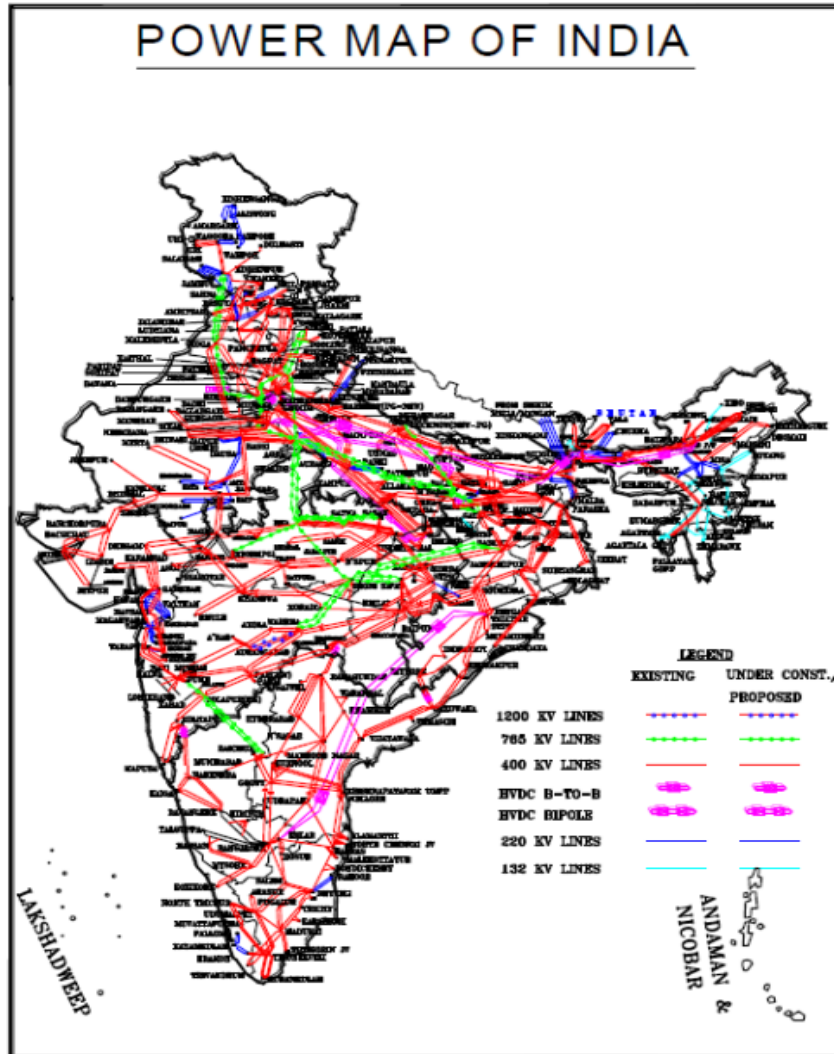


Mitigation Measures for Grid Integration of RE

- ▶ Strong grid inter-connection to enhance balancing
- ▶ Forecasting of renewable generation on different time scale
- ▶ Energy storage: large scale (ex. Pumped Hydro) for balancing of power, fast acting storage for stability
- ▶ Load Management & Demand response
- ▶ Wide area monitoring systems (WAMS) establishing smart grid
- ▶ Establishment of RE management centres integrated with SCADA/control centres.

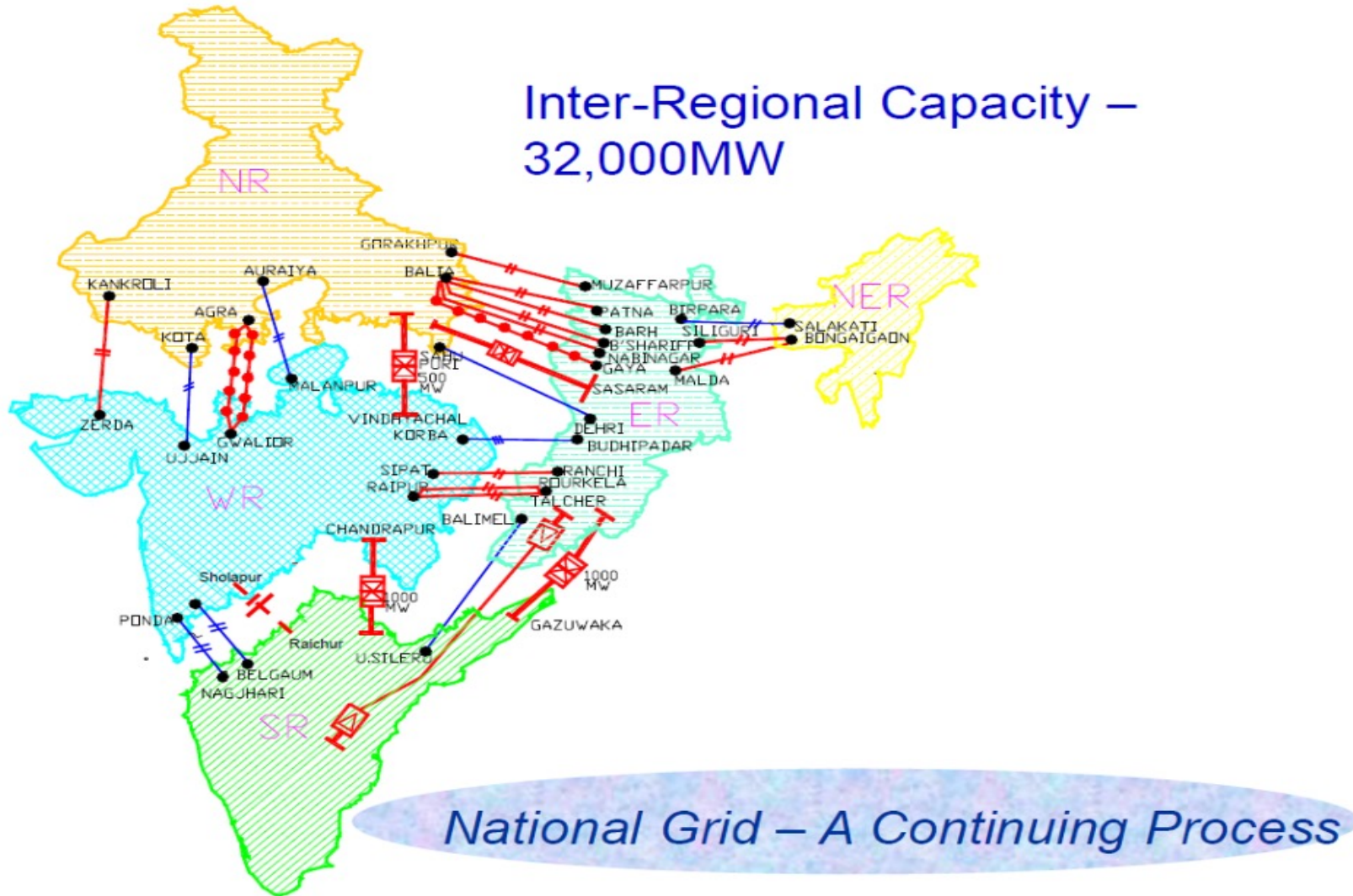


India's Transmission Network



- 765kV lines : 8,056 ckms
- 400kV lines : 1,25,039 ckms
- 220kV lines : 144,966 ckms
- HVDC Bipole (± 500 kV): 9,432 ckms – 5 no. (10,500 MW)
- HVDC Back-to-back : 7 nos., (3000MW)
- Transformation Capacity: 4,79,411 MVA
- FSC – 33 nos.; TCSC – 6 nos.

Inter Regional Power Transfer Capacity



National Grid – A Continuing Process

Power Transfer Capacity With Neighbouring Countries

❑ Existing

- **India – Bhutan** : Upto 1480MW from Tala(1020), Chukha(336) and Kurichu(60) through 400, 220 & 132kV lines.
- **India – Nepal** : About 120-150MW power exchange under radial mode through 132, 33 & 11kV links.
- **India – Bangladesh** : Upto 500MW exchange through 400kV D/c line and HVDC B/b Station

❑ On-going :

- **India – Bhutan** : 400kV inter-connection and Alipurduar HVDC station (3000MW) for Punatsangchu(1200 MW) project.
- **India – Nepal** : 400kV Muzaffarpur(India) - Dhalkebar(Nepal) inter-connection

❑ Future :

- **India – Bhutan** - Masterplan made for evacuation of about 11,500 MW (from 14 HEP) by 2020 and 26,500 MW (from 75 HEPs) by 2030.
 - **India – Nepal** : High capacity transmission interconnection is being planned for evacuation from future about 20,000MW hydel projects in Nepal.
- **India – Sri Lanka** : Feasibility Study carried out for ± 400 kV, 1000MW HVDC bipole interconnection between India(Madurai) and Sri Lanka (Anuradhapura).



Status of various issues that need to be addressed

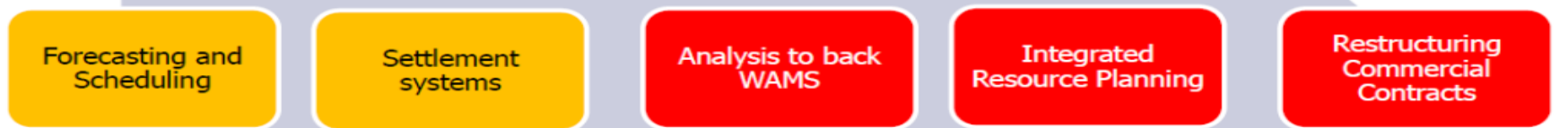
1 Policy and Regulatory Interventions



2 Infrastructure: Hardware and Controls



3 Institutional: Core Business Processes



4 Markets



Already notified/ adequate

Under process/needs improvement

Yet to be taken up

Thank You

