21st Century POWER PARTNERSHIP
Accelerating the transformation of power systems

Achieving Energy System Integration and Interaction

Intelligent Market Design—Boosting Global Smart Grid Deployment

CEM9
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Malmo
National Renewable Energy Laboratory
Operating Agent for the 21CPP

National Renewable Energy Laboratory in Colorado

Background: 21CPP Objectives:

Power System Transformation

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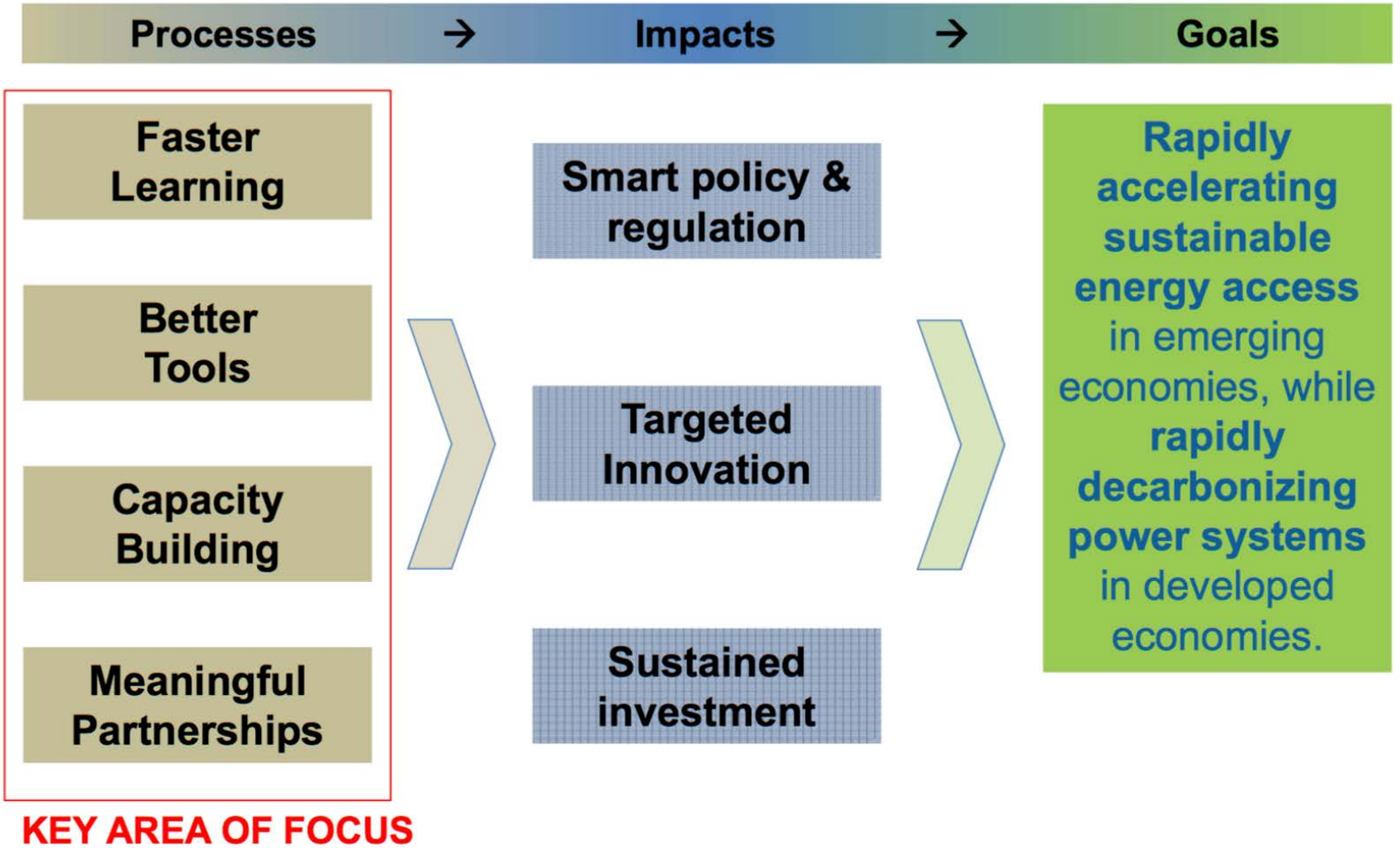

21CPP Work Streams

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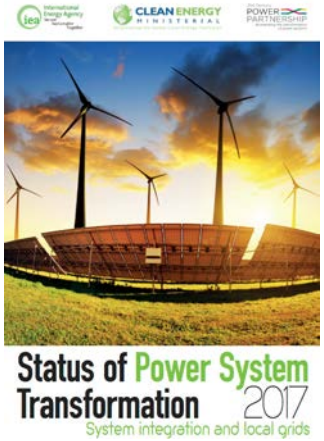
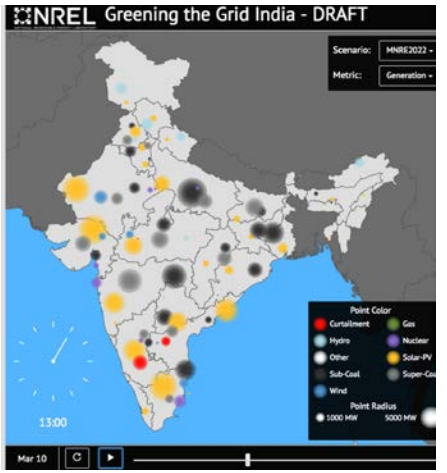
- Annual Program of Work Includes:
- "Thought-Leadership" studies that focus on generic **power system transformation** topics across the world
- In-country technical assistance, often as part of a larger development assistance effort, focused on policy, regulatory, and technological progress; **grid integration studies often highlight this work**.
- Information exchange, capacity building, fellowship programs, and other exercises to **share lessons-learned** and knowledge transfer.





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Accelerating the Transition to Clean Energy Technologies

Brazil | China | India (co-lead) | Denmark | Finland | Mexico (co-lead) | South Africa | Spain | United States (co-lead, under review)

WHY IS GRID INTEGRATION IMPORTANT?

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- Wind and solar are **variable** – the wind and sunlight change.
- Wind and solar energy are **uncertain** – we can forecast them reasonably well for time periods ranging from minutes, hours, a few days.
- **Grid integration** is the practice of developing efficient ways to deliver high penetration levels of variable RE to the grid.
- The variable and uncertain nature of wind/solar require additional power system flexibility…

Advancing Grid Integration

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Goal: help guide states, regions, and countries address typical questions:

- What is the optimal mix of generation resources under various scenarios of policy, technology pathways, fuel prices, etc.?
- How can we add wind and solar in a cost-effective manner?
- What is the capacity value of RE? How can we still have a reliable grid?
- Where should we locate generation and transmission?
- What operational and technology changes are needed to ensure an economic and reliable grid?

Solutions to Grid Integration Challenges

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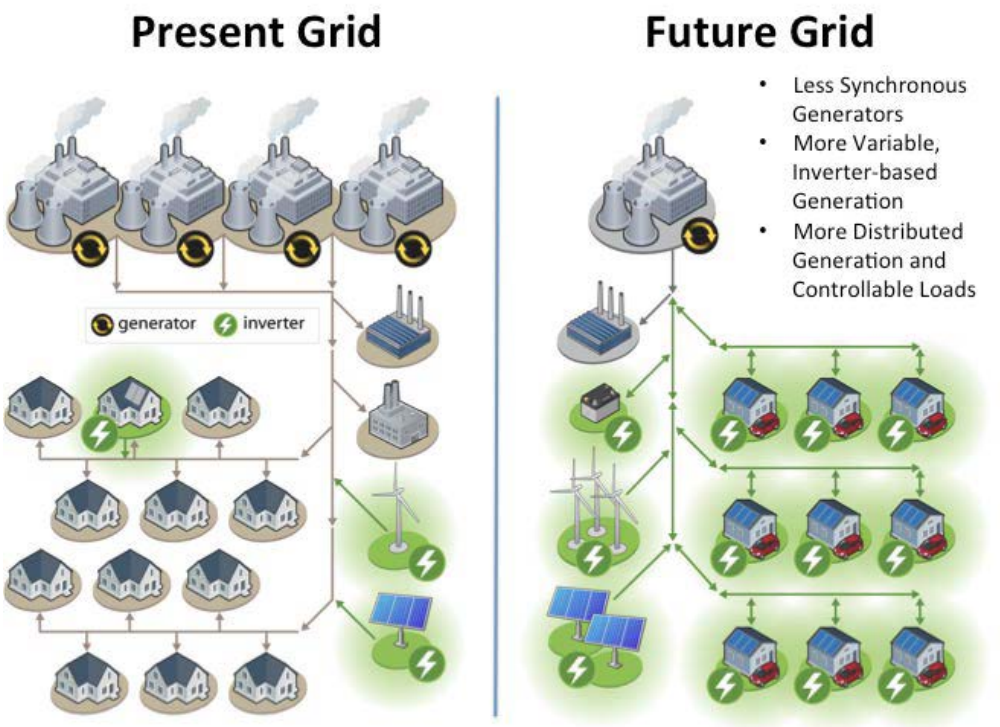

- Utilize geographic diversity.
- Utilize flexible conventional generation.
- Increase sharing among balancing authority areas.
- Expand the transmission system.
- Curtail excess VRE production.
- Coordinate flexible loads (active demand response).
- Enhance VRE and load forecasting.
- Add electrical storage.
- Interact with other energy carriers.

Toolkit to Enable VRE Grid Integration and Relative Costs

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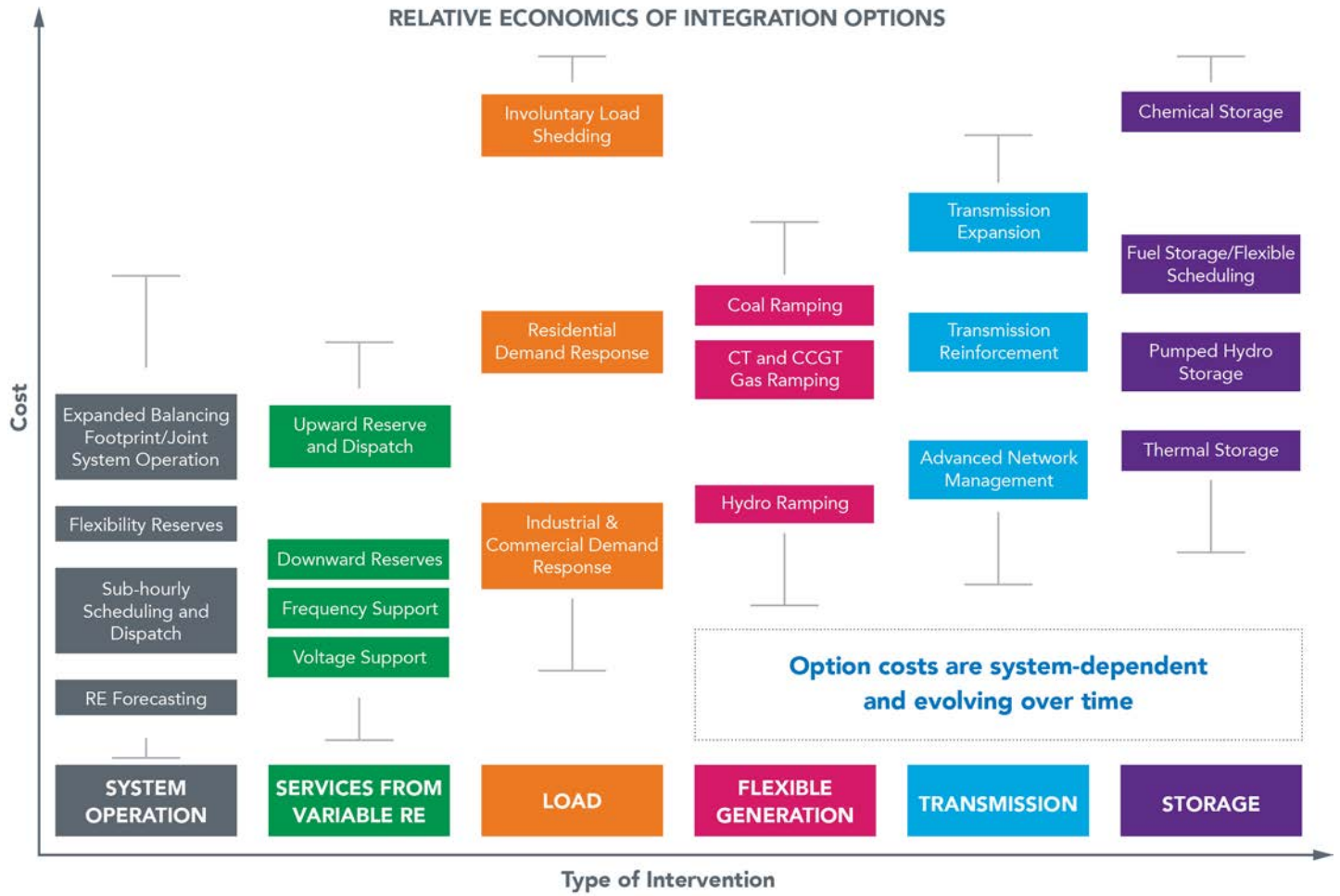

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Key Building Blocks for Grid Integration

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Ambition and Confidence	Deployment and Capacity Building	Grid Infrastructure	Short-term System Flexibility	Long-term System Performance
This area refers to actions related to developing visionary renewable energy targets and goals and building political, public, and private sector support for those goals along with power system transformation and renewable energy integration. This area also includes advocacy and analysis that validates plus builds confidence in the goals along with demonstration programs designed to help further build support and confidence.	This area refers to actions related to supporting and incentivizing the deployment of variable renewable energy including financial support and simplified procedures for siting, interconnection, permitting, financing, etc. It also refers to actions to build private sector market capacity such as training, education, and standardization to reduce risk and costs as well as to increase the speed and scale of VRE deployment.	This area refers to actions related to the changes needed to grid infrastructure for power system transformation and renewable energy integration. This can include actions such as expanded balancing areas which can require physical and market integration, transmission and distribution system expansion/upgrades, renewable energy grid zones, and changes to markets to reduce congestion on the grid.	This area refers to actions related to increasing the ability of the power system to balance load and generation in the short term, e.g. minute and hour timescales. The actions relate to changes to markets and generation such that the power system is able to better manage the short term variability of renewable energy by incentivizing or mandating adjustments to generation and load.	This area refers to actions related to improving the long term e.g. days or years performance of the power system to operate more efficiently and reliability and with more renewable energy. This includes actions such as re-design of markets, long term resource adequacy planning, and grid integration studies

Good Practices for VRE Grid Integration

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VRE Integration Area	Good Practices	Possible High Impacts Interventions
Deployment and Capacity Building	Dispersion and diversification of VRE	• Conduct predevelopment work to encourage VRE in target locations • Promote policies to incentivize diversified VRE resources
	Simple, open, and fast processes	• Improve existing procedures for permitting, interconnection, and siting
Grid Infrastructure	VRE grid support and codes	• Promulgate rules for VRE generators to provide grid support capability • Develop markets to incentivize grid support or requirements to mandate it
	Designated transmission zones	• Develop and promote strategy for RE zones based on resources and existing generation and transmission infrastructure
	Expanded balancing areas	• Develop and promote strategy to expand balancing areas
	Coordinated generation and grid planning with public engagement	• Coordinate and develop plans to jointly build generation and transmission while engaging in public outreach to build support
Short term system flexibility	Economic Dispatch of VRE	• Promote enforcement and execution of economic dispatch policies
	Accurate VRE Forecasting	• Improve forecasting accuracy and develop foresting requirements
	Higher resolution dispatching	• Illustrate benefits of faster dispatching and promote adoption
	Demand side management	• Illustrate benefits of demand response, promote adoption, and develop demonstration programs
	Flexible conventional generation	• Promote investments in conventional generation fleet to improve flexibility • Develop markets to reward flexibility or requirements to mandate flexibility
Long term system performance	Grid integration studies	• Conduct vision and technical integration/market design studies to build confidence and ambition for more RE deployment
	Efficient system and market design informed by analysis	• System and market improvement insights to raise ambition for deeper VRE deployment across broad landscape of policy issues