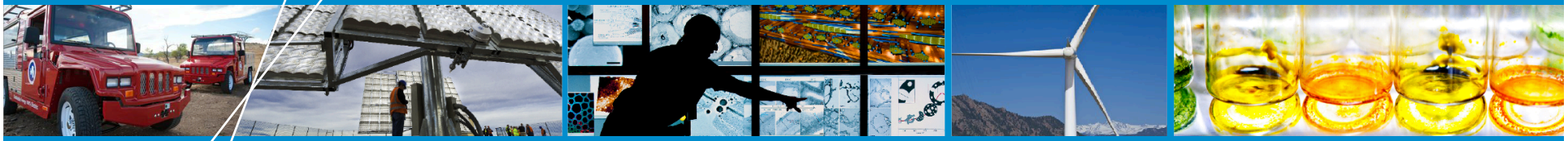
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Policies and Programs to Integrate High Penetrations of Variable Renewable Energy



Jaquelin Cochran, Charles Newcomb

ISGAN "How2Guide" workshop

28 March 2012

Goals of Project

- Highlight approaches for enabling high renewable energy penetration
- Synthesize lessons on effective policies and programs
- Present avenues for action to energy ministers and other stakeholders

Approach

- Case studies
  - Australia
  - Denmark
  - Germany
  - Ireland
  - Spain
  - United States: Colorado & Texas
- Extensive stakeholder consultations

Sponsors and Expert Team

- Supported by the Clean Energy Ministerial

Australian Government
Department of Resources, Energy and Tourism

U.S. DEPARTMENT OF ENERGY

- Experts from diverse institutions:

Australian Energy Market Operator, Bloomberg New Energy Finance, Energinet.dk, Global Green Growth Institute, International Energy Agency, Institute for Sustainable Energy Policies, Johns Hopkins University, National Renewable Energy Laboratory, REN21, Risø, Spanish Ministry of Industry, Energy, and Tourism, United Nations Environment Programme, UNIDO, University College Dublin, University New South Wales, Utility Variable Generation Integration Group, VTT Finland, World Economic Forum

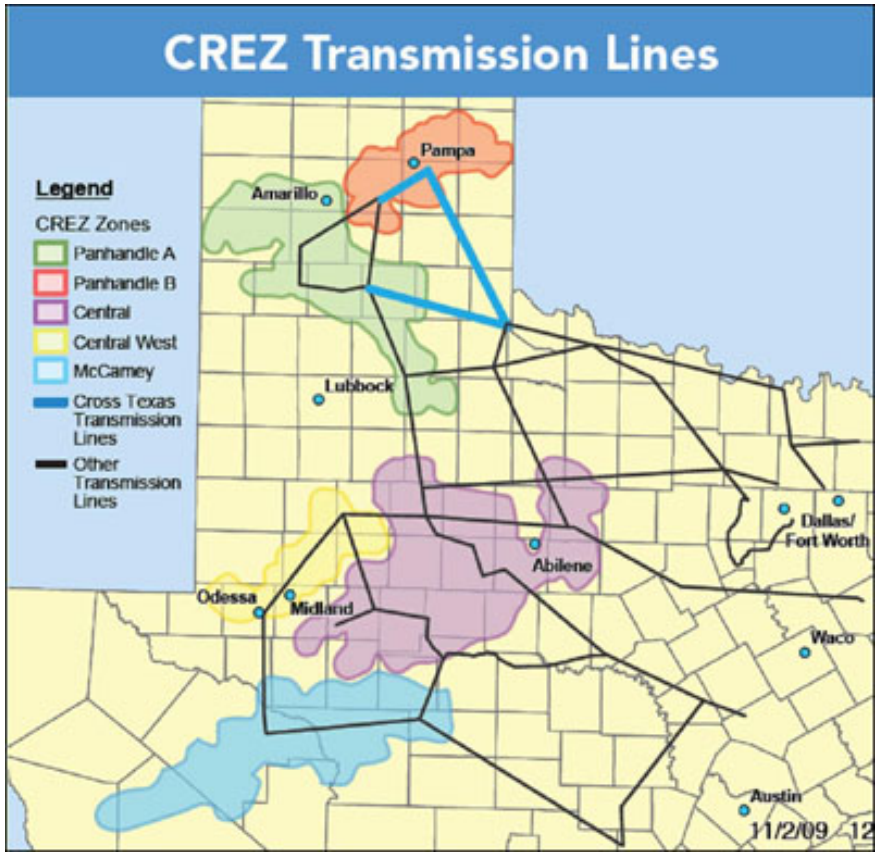
Actions to Accommodate High RE

A. Lead public engagement, particularly for new transmission
B. Coordinate and integrate planning
C. Develop rules for market evolution that enable system flexibility
D. Expand access to diverse resources and geographic footprint of operations
E. Improve system operations

Actions Reflect Market Status

	Public Outreach	Planning	Market Rules	Expanded Access	System Operations
At LOW RE Penetrations	Involve public stakeholders in planning	Evaluate system flexibility, penetration scenarios, transmission needs, and future flexibility needs	Evaluate market design and implications for higher penetrations of RE	Assess renewable energy resources and options for encouraging geographic diversity	Build capacity of grid operator staff; review regulatory changes needed to require advanced forecasting
At MEDIUM RE Penetrations	Communicate to public why new transmission is essential	Regulatory and legislative changes needed to accommodate revised scenario planning, such as laws to support renewable energy zones (REZs)	Ensure that market design and pricing environment aligns with technical needs, such as accessing flexibility, minimizing uncertainty, and managing risk	Make necessary regulatory, market, or institutional changes	Implement grid codes to accommodate high penetrations of variable RE
At HIGH RE Penetrations		Monitor and review effectiveness of actions; revise	Make additional changes to market rules to meet technical needs, such as accessing flexibility, minimizing uncertainty, and managing risk	Ensure broad systems solutions are sought, including smart grid/demand response, storage, and complementary flexible generators	

A. Lead Public Engagement, New Transmission



Case Study: Texas

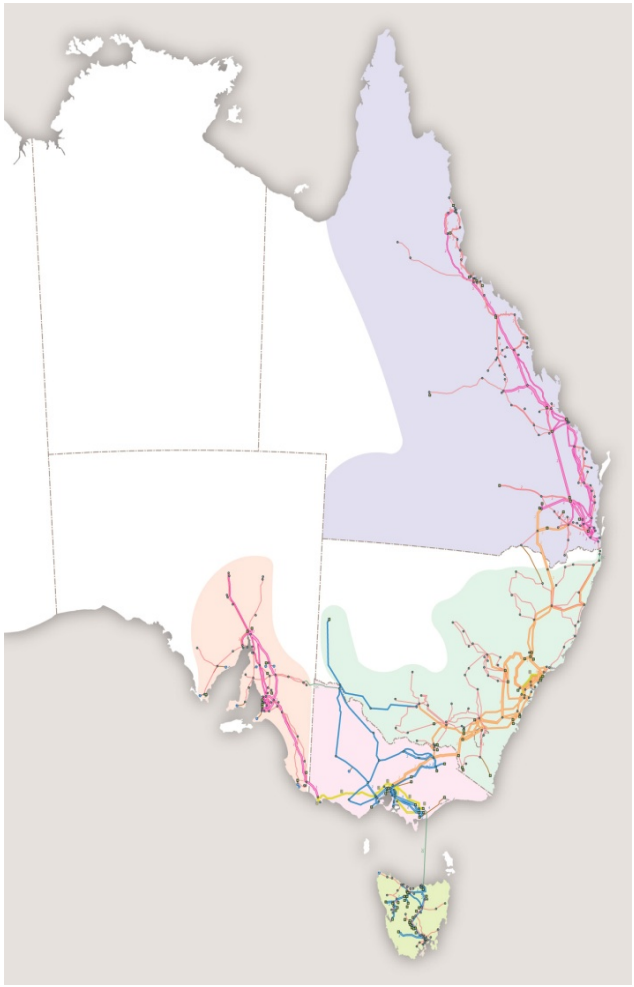
- CREZ: 18.5 GW gen→ 3000 miles trans; 8 years start-to-finish
- Open houses with two-way communication
- Questionnaires, letters, testimony
- Primarily private lands, no NEPA
- Objections limited to location, not purpose

Best Practices

- Involve stakeholders early in process (options analysis)
- Include the objectives of the grid expansion (focus on public benefit)
- Clearly communicate costs/benefits of options
- Maximize transparency of process

Communicate to the public why new transmission is essential

B. Coordinate and Integrate Planning



Case Study: Australia

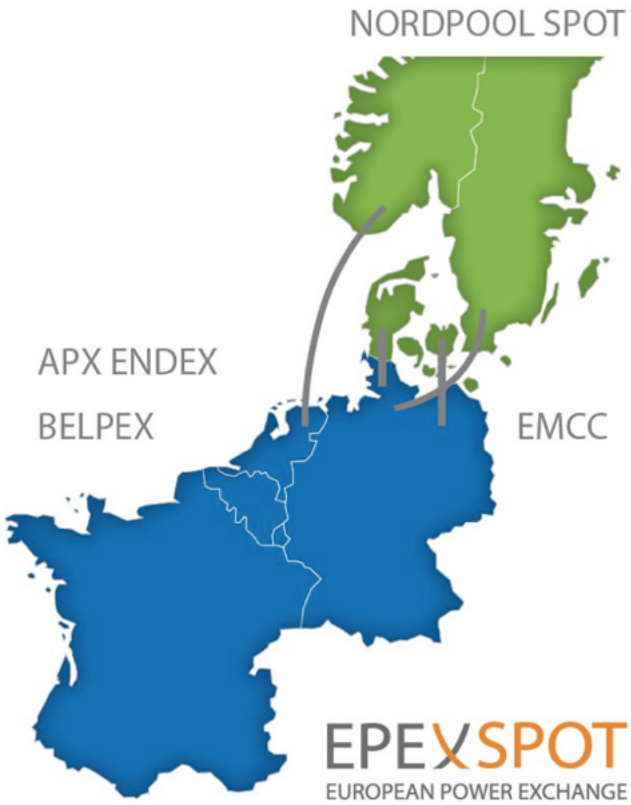
- Utilization of market-based information; national approach
- Australian Energy Market Operator develops National Transmission Network Development Plan
  - Highlights economically efficient locations (forecast-based)
  - Uses benchmarked technology and network development costs

Best Practices

- Clarify planning objectives at system-level
- Promote alignment of generation and transmission planning
- Assess/communicate ability for RE to contribute to system reliability

Improve capacity of planners to handle added complexity and coordination

C. Market Design for System Flexibility



Case study: Denmark

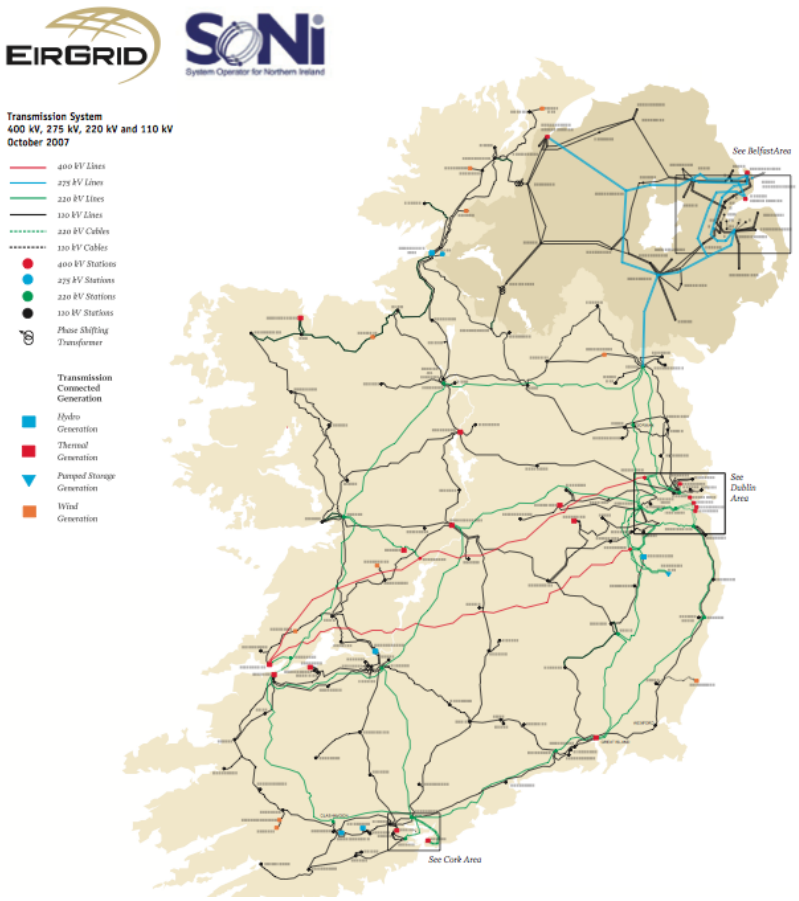
- Nord Pool, market coupling with Central West European market
- Regulating Power Market up to 15 minutes before delivery
- Imbalance penalty
- Negative prices permitted in day-ahead markets
- CHP must participate in spot power market; district heating as source of flexibility

Best Practices

- Shorter schedules, nodal pricing, RE-favorable imbalance penalties, flexibility as part of resource planning
- Utilize demand response/smart grid capabilities (reduce ramping/curtailments, increased penetration)

Commission studies to identify potential impacts of variable generation on electricity markets and generator compensation

D. Expand Diversity, Geographic Footprint



Case Study: Ireland

Single Electricity Market (SEM) with Northern Ireland:

- Expanded balancing area in 2007
- Required for all electricity >10 MW sold and bought in Ireland; no bilateral transactions permitted
- Operates with dual currencies and jurisdictions

East-west interconnector to U.K.

- 500 MW, operational Q3 2012

Best Practices

- Enlarge balancing area
- Interconnect smaller/isolated systems
- Leverage renewable energy zone planning
- Utilize incentives to focus RE development in strategic areas

Evaluate options for overcoming institutional challenges in merging or increasing cooperation among balancing areas

E. Improve System Operations

Case study: Spain

Control Centre for Renewable Energies

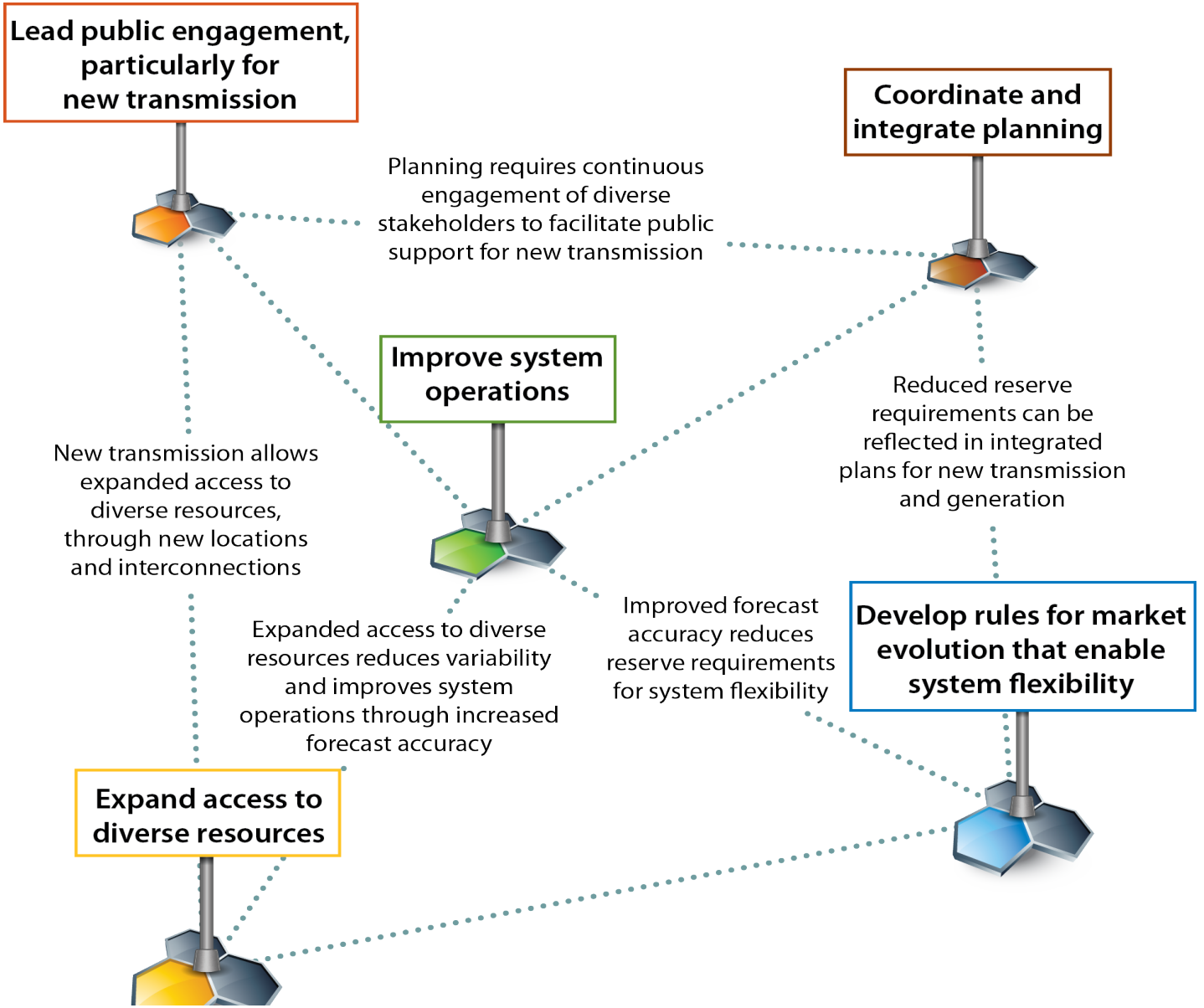
- Monitors RE installations real-time
- Wind farms >10 MW & PV>2MW provide reactive power support
- 97.5% of wind farms have fault-ride through capability
- New operational procedures proposed to maintain optimal voltage control

Best Practices

- Advanced forecasting
  - Increasing accuracy, still best short term
  - Improve communication between RE/Sos
  - Multiple forecasts
  - Refresh forecasting models
- Grid Codes
  - Ride-through requirements, utilize on-board power electronics capabilities (Volt/VAR)

Support outreach on forecasting benefits; training on best practices for grid operators

System-wide Approach More Effective



Key Findings—Actions Champions

1. Commission a comprehensive assessment of the technical, institutional, human capital, and market status and factors influencing renewable energy integration
2. Develop visionary goals and plans at national and regional levels, and empower appropriate leadership to bring the visions to fruition
3. Lead the public engagement to communicate goals and needed actions to attain them
4. Engage in international coordination to share best practices and strengthen technical, human and institutional capabilities to achieve higher levels of renewable energy penetration

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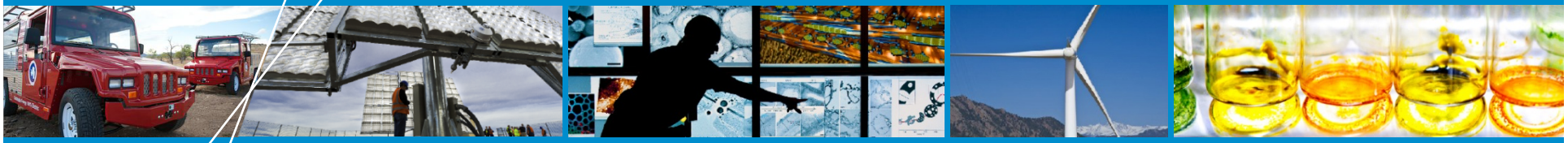

Thank you

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