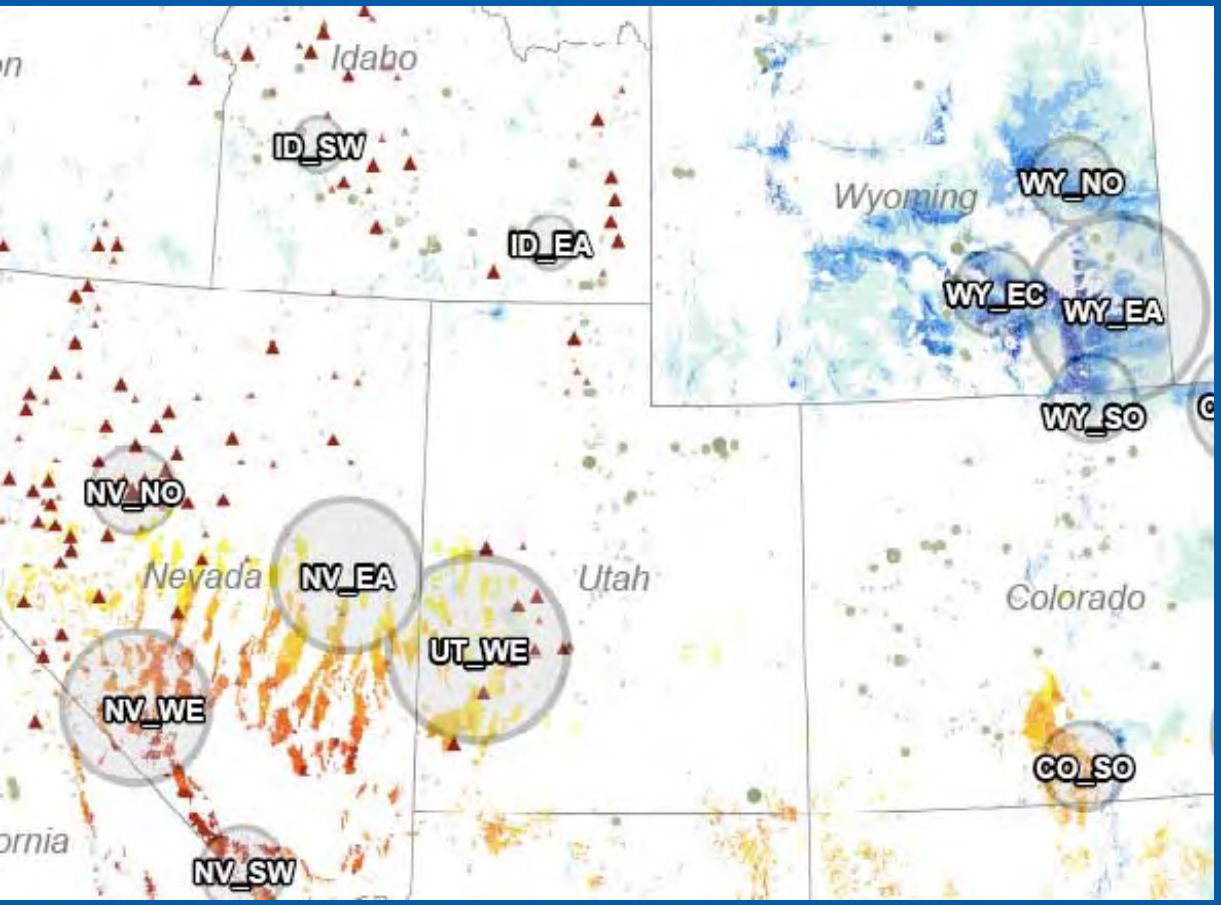
National Renewable Energy Laboratory
Innovation for Our Energy Future

Renewable Energy Strategy in the West



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Utility Energy Forum

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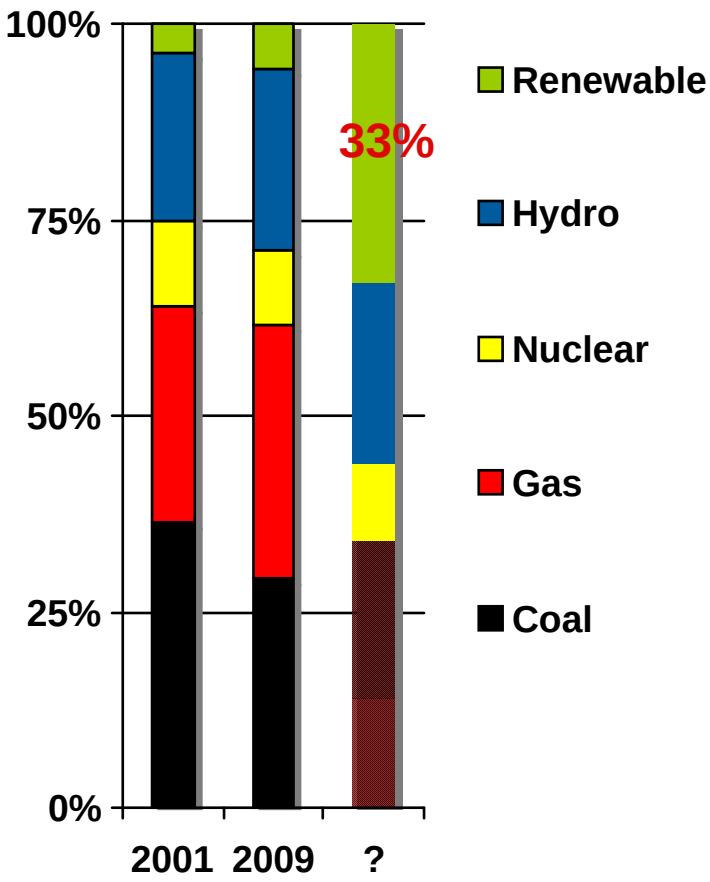
How the West generates power

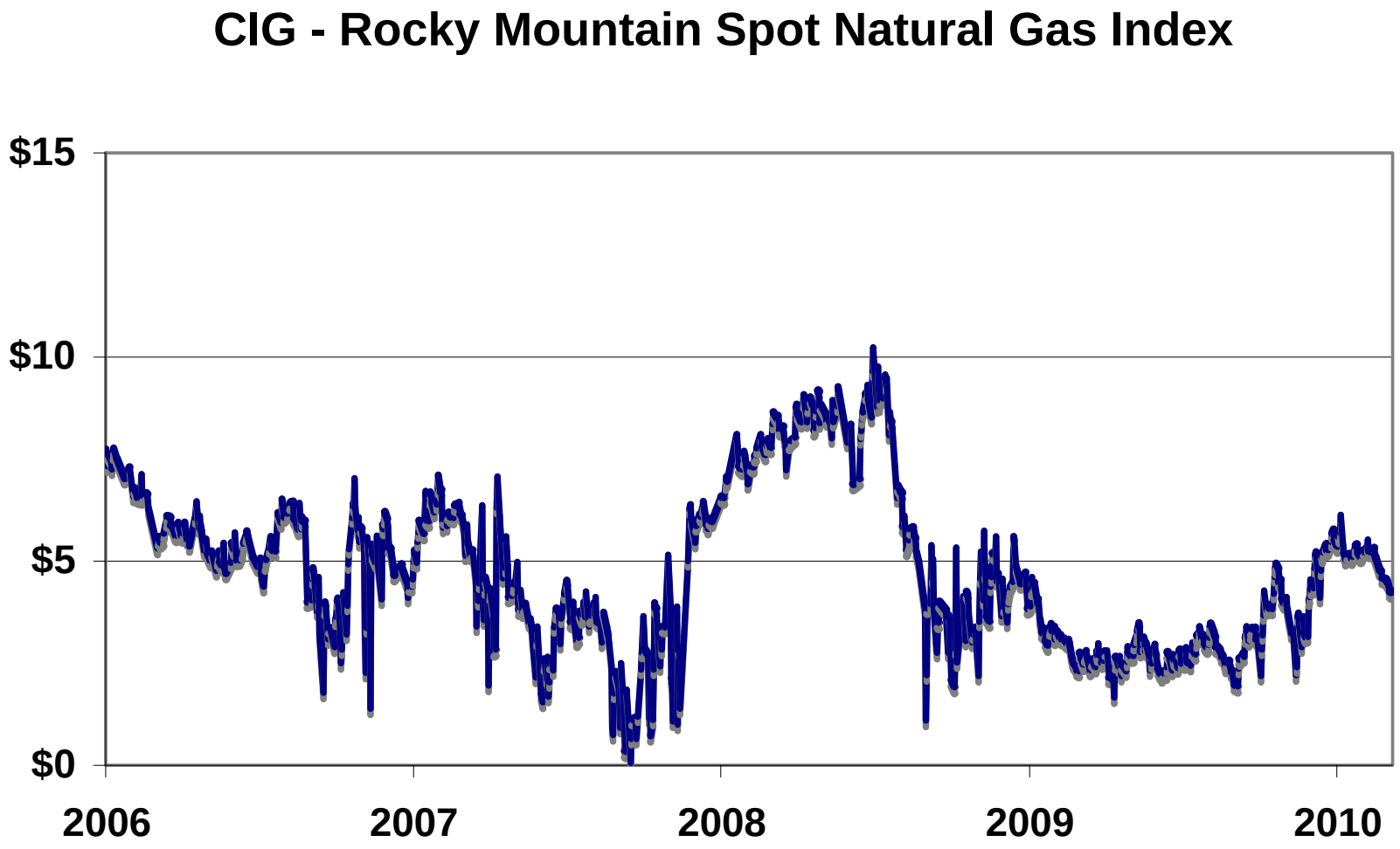
- In 2001, coal was the predominant source (35%)
  - Above 90% in CO, UT, WY
  - Transfers to West Coast were primarily coal base load
- Today coal is less, wind and natural gas are more
- Long-term planning includes renewable energy scenarios of up to 33% for the Western Interconnection as a whole



Path of future cost is uncertain

- What will be the price of carbon?
  - Coal has twice the carbon emissions of natural gas, so the price effect on coal will be double
  - Moderate carbon price alone will not cause an economic shift in the fuel mix
- Where will natural gas prices go?
- Where will the cost of renewable alternatives be?
  - Today, levelized $/MWh for a well-sited wind farm is equivalent to that of a new combined cycle gas turbine with natural gas at $7/mmBtu
  - Well-sited solar thermal in AZ is equivalent to a peaker with natural gas at $10/mmBtu

Path of future cost is uncertain



Path of future cost is uncertain

- How will the western grid be managed?
  - Currently managed within many small areas
  - Small areas make variable resources such as wind and solar harder and more expensive to manage

What's being done?

- Western Governors' Association
  - Western Renewable Energy Zone Initiative
- Western Electricity Coordinating Council
  - Modeling long-term renewable energy penetration scenarios to evaluate reliability issues and solutions
  - Sub-regional planning groups identifying preferred transmission options
- US Department of Energy and national labs
  - In addition to on-going research and analytical support, providing $26.5 million in ARRA funding to WGA and WECC for interconnection-wide transmission planning
  - Western Wind and Solar Integration Study

Wind and Solar Integration Study

- Modeled renewable energy expansion of up to 35% (30% wind, 5% solar), using three scenarios
  - In-state renewables for in-state demand
  - “Mega-project” transmission overlay
  - Hybrid: local priority, some new transmission
- Objective was to look at variability and effect on reliability and reserve requirements
- Geographic focus was on WestConnect footprint
  - NV, AZ, NM, CO, WY
  - Modeled remainder of WECC as a single out-of-footprint resource area

Study findings

- 35% is achievable, but —
  - not without more transmission
  - not without more balancing area coordination
- Forecasting reduces integration costs significantly
- Subhourly scheduling is critical
- 35% does not justify additional storage
  - Arbitrage value (generate off-peak, dispatch on-peak) would not offset cost of new storage
- Among the in-state, mega-project and local priority scenarios,
  - little operational difference
  - Mega-project scenario required 25% less wind capacity than did the in-state scenario

Western Renewable Energy Zones

- ✓ *Phase 1: Identify renewable energy zones (REZs), estimate quantity of REZ resources, estimate busbar cost of REZ resources*
- ✓ *Phase 2: Develop modeling tool to estimate delivered cost of energy from any REZ to any major load center in the West; submit scenarios to WECC for detailed study*
- Phase 3: Assist utilities in coordinating renewable energy procurement plans and new transmission needs
- Phase 4: Institution-building

Western Renewable Energy Zones

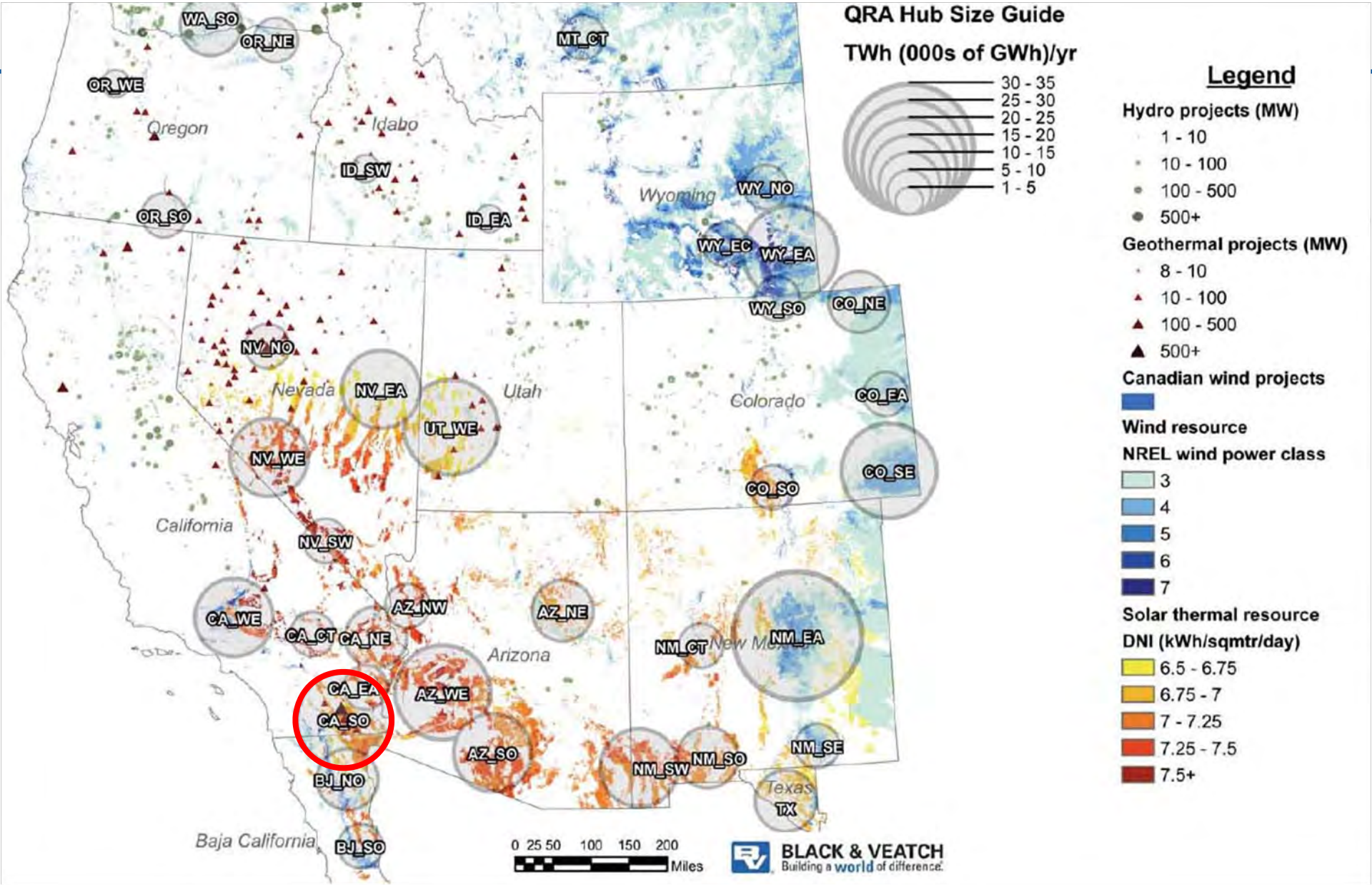
- REZ resources
  - Connected to load via large regional transmission lines crossing several states
  - Multijurisdictional, in that the entire transmission project would require approvals in more than one state
- Non-REZ resources
  - Economical for serving in-state demand
  - Not necessarily in a REZ

Qualifying resources

1. Select wind class threshold, eliminate resources below threshold
2. Identify exclusion areas
   - Technical (land slope is too steep)
   - Existing land use (urban centers, airports)
   - Policy (parks, preservation areas, cultural sites)
3. Apply exclusion filter

Renewable Energy Zones

- A REZ is an area with renewable resources of sufficient quality and sufficient concentration to warrant consideration of interstate transmission
- A REZ **hub** represents a hypothetical transmission substation where the zone's resources are collected
- Estimates of available resources take into account land limitations (environmental, technical) to the extent known
- Discounts applied to remaining screened potential
  - Wind capacity reduced to 25%
  - Solar capacity reduced to 3.5%


QRA Hub Size Guide
TWh (000s of GWh)/yr
30 - 35
25 - 30
20 - 25
15 - 20
10 - 15
5 - 10
1 - 5
Legend
Hydro projects (MW)
1 - 10
10 - 100
100 - 500
500+
Geothermal projects (MW)
8 - 10
10 - 100
100 - 500
500+
Canadian wind projects
Wind resource
NREL wind power class
3
4
5
6
7
Solar thermal resource
DNI (kWh/sqmtr/day)
6.5 - 6.75
6.75 - 7
7 - 7.25
7.25 - 7.5
7.5+
WA_SO
OR_NE
MT_CT
OR_WE
Oregon
Idaho
ID_SW
Wyoming
WY_NO
OR_SO
ID_EA
WY_EC
WY_EA
WY_SO
CO_NE
NV_NO
Nevada
NV_EA
Utah
Colorado
CO_EA
UT_WE
NV_WE
CO_SE
CO_SO
California
NV_SW
AZ_NW
AZ_NE
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Regional transmission scenarios

- Zone hubs and their supply curves went into a conceptual delivered cost model
  - Excel-based
  - Populated with busbar costs from Phase 1, but may be customized to capture user-defined projects or scenarios
  - Delivered costs estimated on the basis of user-selected load hub and user-selected REZ hub
  - Available to load-serving entities and regulators to test scenarios

Next steps

- Engage load-serving entities, transmission planners and regulators in analysis of high-interest renewable energy zones
- Identify institutional barriers to regional planning for transmission to renewable energy zones

Questions?