Regulatory Barriers to Large Scale Renewable Energy Deployment in the United States

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Outline of Talk

- Introduction to Program on Energy and Sustainable Development (PESD)
- PESD research area--Three regulatory barriers to large scale renewable energy deployment
  - Transmission planning, expansion, and pricing
  - Renewable Energy Credit (REC) market
  - Symmetric treatment of load and generation
- Outline ongoing PESD research on how reduce these barriers

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It's Not Just About Technology…

- Technology is a key part of energy solutions, but technologies can't always be implemented
- Examples of technologically-feasible solutions that are hindered by regulatory and political constraints:
  - Carbon pricing
  - Transmission expansions to support renewable energy deployment
  - Dynamic pricing of electricity to final consumers
  - Carbon capture and storage (CCS) at scale

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What is PESD?

- Research on production and consumption of energy and its impact on the environment from a multi-disciplinary perspective
  - Economics
  - Political Science
  - Business
  - Law / Regulatory Analysis
- Part of Freeman Spogli Institute of International Studies since 2001
- All energy and environmental challenges have a significant public policy component

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What PESD Does: Content Areas

- Climate policy: international, national, state, and local
- Transmission expansion to facilitate renewable energy
- "Smart grid": Dynamic electricity pricing & demand response
- Reducing the carbon content of transportation
- The role of national oil companies in the world oil market
- The potential of natural gas for climate mitigation
- The global coal market and implications for climate
- Technology diffusion and innovation in low-carbon energy
- Energy services for the poor
- Adaptation to climate change

What PESD Does: Research Spanning Disciplines

ECONOMICS

- Electricity market design
- Econometric analysis of behavior
- Models of global energy markets
- Least-cost options for carbon mitigation
- Innovation and tech diffusion theory

POLITICAL SCIENCE

- Energy/climate and international relations
- Systems of government and energy markets
- Corruption & interest group influence

BUSINESS STRATEGY

- Business models for sustainable energy
- Effect of policy and regulatory environment on business viability
- Commercial models for serving the poor
- State-owned enterprises in energy

LEGAL/REGULATORY ANALYSIS

- Regulation and fragmented jurisdictions
- Lessons learned from other jurisdictions
- Analysis of incentive structures and policy/regulatory designs to align them
- Policy/regulatory design for innovation

Sample PESD Research: Economics

- Electricity market design
  - Why dynamic pricing is far more efficient than conventional demand response measures *(Bushnell, Hobbs, and Wolak 2009)*
  - Reforming the New Zealand electricity supply industry *(Wolak 2009)*
- Econometric analysis of consumer behavior
  - Consumer response to dynamic pricing of electricity *(PowerCents DC: Wolak 2010)*
  - Trends in energy demand in the US, UK, China, and India *(Wolak, Chung, Thurber)*
- Least-cost options for carbon mitigation
  - Effects of climate policy uncertainty on US energy mix *(Wolak and Morse 2011)*
  - Comparing upstream vs. downstream CO_2 trading *(Hobbs, Bushnell & Wolak 2010)*
  - Low-carbon fuel standards *(Wolak 2008)*
- Mathematical models of global energy markets
  - Model of China's coal import behavior *(Morse and He 2010)*
  - World coal model *(Haftendorn et al 2010)*
  - World coal and natural gas model *(Wolak, Zhang, Miller)*
  - Market simulation to assess benefits of transmission upgrades *(Awad et al 2010)*
- Theory of innovation and technology diffusion
  - Extent of learning-by-doing in wind project development *(Anderson)*

Sample PESD Research: Political Science

- Energy/climate and international relations
  - Book: National Oil Companies *(Victor, Hults, and Thurber 2011 forthcoming)*
  - Book: Natural Gas and Geopolitics *(Victor, Jaffe, and Hayes 2006)*
- Systems of government and energy markets
  - Effects of institutional quality and political competition on oil sector performance *(Thurber, Hults, and Heller 2010)*
  - Influence of regime type on expropriation and privatization choices *(Warshaw 2011 forthcoming)*
- Influence of interest groups on policy / Corruption
  - "An ethanol policy that benefits all Americans" *(Wolak 2007)*
  - How Nigerian interests preserve the country's dysfunctional status quo in oil *(Thurber, Emelife, and Heller 2010)*
  - Do patronage networks replace regulators in states with weak institutions? *(Kjærnet and Thurber)*

Sample PESD Research: Business Strategy

- Business models for sustainable energy
  - Book: Distributed generation business models for rural electrification *(Zerriffi 2011)*
  - Risk and the business models of private vs. state oil companies *(Nolan and Thurber 2010)*
- Effect of policy and regulatory environment on business viability
  - How Indonesia's regulatory history has shaped its coal industry *(Lucarelli 2011)*
- Commercial models for energy services to the poor
  - Assessing the viability of commercial cookstove sellers in India *(Shrimali, Slaski, Thurber, and Zerriffi 2011 forthcoming)*
  - Uptake and utilization of improved biomass stoves in Maharashtra and Karnataka *(Thurber and Phadke)*
  - Why are some products easier to sell to the poor than others? (*Slaski and Thurber 2009)*
- State-owned enterprises in energy
  - Norway's Statoil and the politics of state enterprise *(Thurber and Istad 2010)*
  - Vertical integration in China's coal-to-power value chain *(Rui, Morse, and He 2010)*
  - The crucial role of institutional structure in China's coal and power sectors *(Peng 2009)*

Sample PESD Research: Regulatory Analysis

- Federalism: How interactions between jurisdictions and different levels of government shape the policy & regulatory environment
  - Tom/Kat grant: transmission modeling & regulatory analysis *(Wolak, Thurber, Boyd)*
- Lessons learned from other jurisdictions
  - Comparative analysis of natural gas market design in Asia *(Thurber and Chang 2011)*
- Analysis of incentive structures to predict market outcomes
  - What China really wants from CCS *(Morse, Rai, and He 2009)*
  - Why carbon offsets for Chinese wind projects aren't working *(Morse and He 2010)*
  - Flaws in the Clean Development Mechanism (CDM) *(Wara 2008)*
- Policy/regulatory designs to properly align incentives
  - Key regulatory changes needed to encourage low-carbon energy *(Wolak 2010)*
- Policy/regulatory design to foster technology innovation
  - Factors affecting the adoption of carbon capture and storage (CCS) technology *(Rai, Victor, and Thurber 2009)*

What PESD Does: Teaching and Training

- Courses
  - ➢ Stanford Law School

    Regulatory Economics (focus on energy & infrastructure industries)
  - ➢ Stanford Graduate School of Business

    Business Models for Sustainable Energy
    - 60 students from MBA and Sloan programs + graduate students from other energy-related fields
    - Focus on intersection of technology, economics, politics, and legal/regulatory framework in determining viability of an energy business
- Graduate Student Research

  PESD research currently engages 4 graduate researchers from Economics, 2 graduate researchers from International Policy Studies, 1 graduate researcher from Political Science / Law

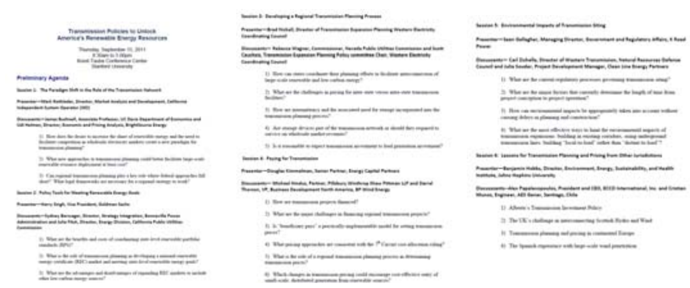
PESD Research

- Regulatory, political and economic policy focus of PESD requires significant off-front investment in industry and institutional knowledge
  - Full-time researchers that follow specific energy and environmental sectors
    - Electricity supply industry
    - Oil and natural gas markets
    - Coal markets
    - Environmental regulations and markets
- Unique feature of PESD relative to other academic research centers
  - Crucial to making research relevant to policy-making process

What PESD Does:
Policy Outreach & Impact (part 1)

- Annual research conference
  - Transfer best available academic research to industry and policymakers
  - September 7th, 2010: “Climate Policy Instruments in the Real World”
    - The relative merits of different carbon pricing mechanisms
    - Engaging the developing world in climate mitigation
    - The role of renewable energy in climate mitigation
    - Reducing greenhouse gases from the transportation sector
    - Managing intermittency in the electricity sector
    - Adaptation
  - September 15, 2011 conference co-sponsored by TomKat, Precourt, Kauffman, Pillsbury, SIEPR, “Transmission Policies to Unlock America’s Renewable Resources”
    - Limited space available for interested graduate students
- Bi-monthly newsletter summarizing PESD research results

Annual Conference Agenda—9/15/2011



Speakers and Discussants from: Electricity Supply Industry, Project Developers, Financial Community, System Operator, Academia, Regulatory Commissions, Legal Experts, Internationally and Domestically

If you would like to attend send your full name and e-mail address to me at wolak@stanford.edu. First 10 will be admitted.

What PESD Does:
Policy Outreach & Impact (part 2)

- Op-eds / policy briefs / citations in major periodicals

  Including: The New York Times, The Wall Street Journal, The Guardian, The Financial Times, The Jakarta Post, Bloomberg Energy, Energy Compass, The San Jose Mercury News

- Advice to governments

  Electricity market design
  - California and other US states
  - Latin America
  - Europe
  - Australia / New Zealand
  - Asia

  Market monitoring protocols
  - California
  - Latin America
  - Australia
  - Asia

Current PESD Research Area: Reducing the Regulatory Barriers to Lower Carbon Energy Services

Lowering the Carbon Content of Energy Services

Two policy approaches:

1) Increase supply of low carbon energy sources
   - Renewable energy: wind, solar, geothermal
   - Other transitions to lower carbon energy: coal → natural gas; natural gas → nuclear
   - Carbon capture and sequestration (CCS)

2) Encourage use of "smart grid" technologies
   - Reduce the carbon content of energy services
   - Use less energy to provide same service
   - Several current research projects on this topic

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Regulatory Barriers to Lowering the Carbon Content of Energy Services

- State and federal transmission expansion policies
  - ➢ Barrier to getting low carbon energy to consumers
- State regulatory policies on dynamic pricing
  - ➢ Barrier to "smart grid" technology and integration of intermittent renewable sources

Eliminating these regulatory barriers requires understanding of relevant technology, economics, and legal/regulatory framework

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Relevant Characteristics of Sun and Wind Power

- <u>Intermittent</u>: Energy not available all the time, only when sunlight or wind are available
- <u>Non-dispatchable</u>: Cannot increase amount of energy produced on demand
- <u>Location specific</u>: Resource only exists at specific locations
- <u>Zero variable cost</u>: No input fuel cost

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Existing Transmission Network Not Designed for Intermittent Renewables

- Current network designed to deliver coal and gas-fired generation with high capacity factors
  - Can also deliver fossil fuels to load center using rail (coal) or pipeline (natural gas)
- Why renewable energy is different
  - Must use transmission network to deliver energy
  - Intermittency requires more interconnected network
- <u>Major paradigm shift</u> in transmission network planning in past ten years due to:
  - Presence of wholesale electricity markets
  - Desire to increase share of renewable energy

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Policy Driver for Increased Renewable Share: Renewable Portfolio Standards

- To increase share of renewable energy, virtually all states have renewable portfolio standards (RPS) that require either:
  - An absolute level of in-state renewable generation capacity
  - A pre-specified share of the total energy consumed in the state to come from renewable sources
- Virtually all are far behind meeting RPS goals
  - States have long interconnection queues for renewable energy resources
  - Existing transmission infrastructure is a major barrier to increasing the amount of renewable energy delivered to major load centers

California's RPS

SB 1078 established the State's First Renewable Portfolio Standard (RPS)

- By the year 2010, 20% of electricity consumed in California must come from renewable resources
  - Investor-owned utilities (IOUs), community choice aggregators, and energy service providers (ESPs) all subject to RPS
  - Publicly owned utilities not subject to 20 percent goal but must implement their own RPS
- SB 2X, which was recently signed into law, sets a goal of 33% of the electricity coming from renewables by 2020
- Renewable Resources include:
  - Wind
  - Solar
  - Geothermal
  - Biomass
  - Small hydro (less than 30 MW)

Summary of State Renewable Portfolio Standards

The following table gives a rough summary of state renewable portfolio standards and links to organizations that are administering these standards or explain the details involved. Percentages refer to a portion of electricity sales and megawatts (MW) to absolute capacity requirements. Most of these standards phase in over years, and the date refers to when the full requirement takes effect.

State	Amount	Year	Organization Administering RPS
Arizona	15%	2025	Arizona Corporation Commission
California	33%	2030	California Energy Commission
Colorado	20%	2020	Colorado Public Utilities Commission
Connecticut	23%	2020	Department of Public Utility Control
District of Columbia	20%	2020	DC Public Service Commission
Delaware	20%	2019	Delaware Energy Office
Hawaii	20%	2020	Hawaii Strategic Industries Division
Iowa	105 MW		Iowa Utilities Board
Illinois	25%	2025	Illinois Department of Commerce
Massachusetts	15%	2020	Massachusetts Division of Energy Resources
Maryland	20%	2022	Maryland Public Service Commission
Maine	40%	2017	Maine Public Utilities Commission
Michigan	10%	2015	Michigan Public Service Commission
Minnesota	25%	2025	Minnesota Department of Commerce
Missouri	15%	2021	Missouri Public Service Commission
Montana	15%	2015	Montana Public Service Commission
New Hampshire	23.8%	2025	New Hampshire Office of Energy and Planning
New Jersey	22.5%	2021	New Jersey Board of Public Utilities
New Mexico	20%	2020	New Mexico Public Regulation Commission
Nevada	20%	2015	Public Utilities Commission of Nevada
New York	24%	2013	New York Public Service Commission
North Carolina	12.5%	2021	North Carolina Utilities Commission
North Dakota*	10%	2015	North Dakota Public Service Commission
Oregon	25%	2025	Oregon Energy Office
Pennsylvania	8%	2020	Pennsylvania Public Utility Commission
Rhode Island	16%	2019	Rhode Island Public Utilities Commission
South Dakota*	10%	2015	South Dakota Public Utility Commission
Texas	5,880 MW	2015	Public Utility Commission of Texas
Utah*	20%	2025	Utah Department of Environmental Quality
Vermont*	10%	2013	Vermont Department of Public Service
Virginia*	12%	2022	Virginia Department of Mines, Minerals, and Energy
Washington	15%	2020	Washington Secretary of State
Wisconsin	10%	2015	Public Service Commission of Wisconsin

*Five states, North Dakota, South Dakota, Utah, Virginia, and Vermont, have set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.

California Did not Meet 2010 Goal

Table 1. Actual Renewable Energy Deliveries in Gigawatt Hours (GWh)

		Verified				IOU Self Reported			
		2003	2004	2005	2006	2007	2008	2009	2010
PG&E	Target (GWh)	7,022	7,733	8,454	9,178	9,941	10,732	11,547	15,554
	RPS-Eligible Procurement (GWh)	8,686	8,660	8,707	9,118	9,044	9,817	11,493	13,760
	RPS % of Bundled Sales	11.5%	12.2%	12.1%	12.6%	11.8%	12.4%	14.1%	17.7%
	Cumulative Deficit/Surplus (GWh)	1,664	2,592	2,844	2,785	1,888	973	919	-876
SCE	Target (GWh)	11,254	11,960	12,690	13,440	14,228	15,023	15,833	15,028
	RPS-Eligible Procurement (GWh)	12,421	13,182	12,882	12,486	12,261	12,574	13,622	14,548
	RPS % of Bundled Sales	16.6%	18.7%	17.6%	16.6%	15.5%	15.8%	16.8%	19.4%
	Cumulative Deficit/Surplus (GWh)	1,167	2,390	2,522	1,569	-399	-2,848	-5,058	-5,538
SDG&E	Target (GWh)	296	447	605	765	933	1,104	1,278	3,257
	RPS-Eligible Procurement (GWh)	550	678	825	900	881	1,047	1,784	1,940
	RPS % of Bundled Sales	3.7%	4.3%	5.2%	5.6%	5.2%	6.1%	10.2%	11.9%
	Cumulative Deficit/Surplus (GWh)	254	485	706	841	788	732	1,239	- 78
TOTAL	Target (GWh)	18,572	20,139	21,748	23,382	25,102	26,859	26,900	33,839
	RPS-Eligible Procurement (GWh)	21,657	22,520	22,354	22,504	22,185	23,438	26,844	30,249
	RPS % of Bundled Sales	13.8%	14.1%	13.7%	13.1%	12.6%	13.0%	15.4%	17.9%
	Cumulative Deficit/Surplus (GWh)	3,085	5,466	6,072	5,194	2,277	-1,143	-2,900	-6,492

Explaining Renewable Share Increase from 2008 to 2010

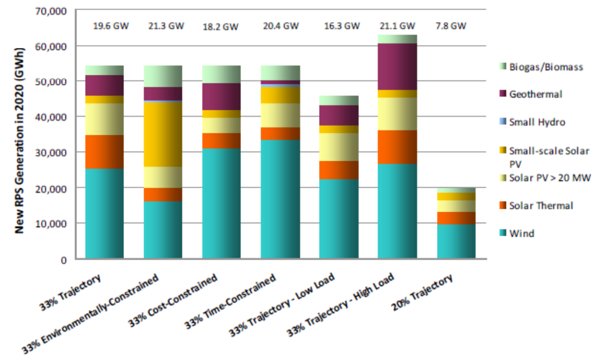
CAISO Annual Load Statistics for 2006-2010

Year	Annual total energy (GWh)	Average load (MW)	% change	Annual peak load (MW)	% change
2006	241,019	27,432		50,270	
2007	242,880	27,644	0.8%	48,615	-3.3%
2008	241,128	27,526	-0.4%	46,897	-3.5%
2009	230,754	26,342	-4.3%	46,042	-1.8%
2010	224,922	25,676	-2.5%	47,350	2.8%

- Lower level of economic activity in 2009 than in 2008
  - Led to 4.3% decline in load (lower denominator)
  - Fewer hours when renewable units were constrained off (higher numerator)
- Lower level of economic activity in 2010 than in 2009
  - Led to 2.5% decline in load (lower denominator)
  - Fewer hours when renewable units were constrained off (higher numerator)

Forecast Generation by Technology

Figure 3. New Resources to Meet 33% and 20% RPS Scenarios in 2020



From 2003-2011 approximately 2,000 MW of Added in CA under RPS Program

Barriers to Meeting RPS Goals (Within California)

- Transmission lines needed to access major renewable regions
  - Tehachapi region has close to 4,500 MW wind potential
    - Existing transmission capacity from region inadequate for resource potential
  - Imperial Valley region has significant geothermal and solar resource potential
    - Existing transmission capacity from region inadequate for resource potential

Regulatory Barriers (Within California)

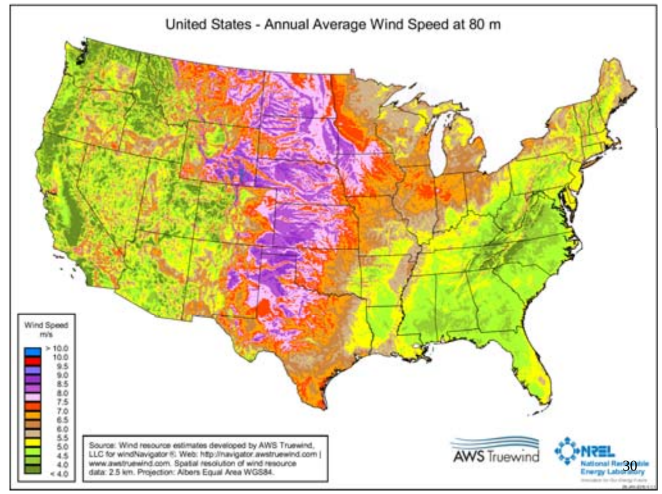
- Transmission expansion process is extremely costly and time-consuming
  - California process for transmission planning and expansion unsuited to current wholesale market
    - Ignores state-wide and regional benefits of expansion in cost-benefit analysis
    - Does not account for market competitiveness benefits
    - Does not adequately deal with insurance value of upgrades
- Cost of California's transmission network is roughly 10 percent of average retail price
  - Expansions increase competitiveness of wholesale market
    - Wolak, F.A., "The Benefits of an Electron Superhighway" see web-site
  - Potential "free lunch"
    - Expanding transmission network increases transmission costs, but wholesale prices are lower due to increased competitiveness of wholesale market brought about by expansions

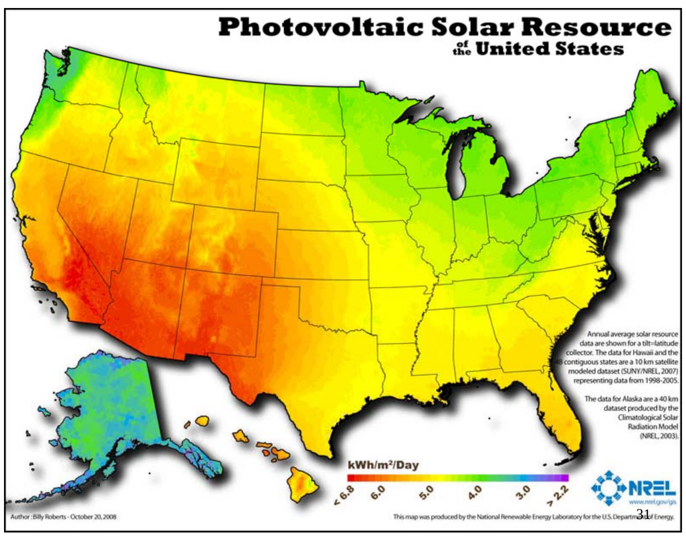
Regional Barriers

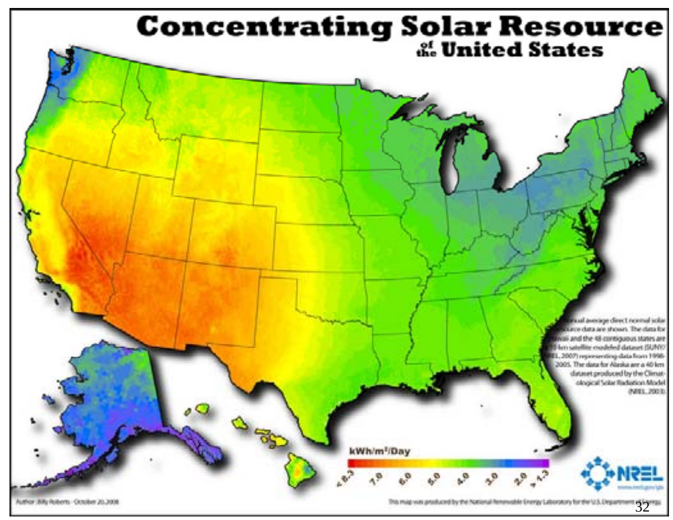
- Major wind and solar resources in the US tend to be where population density is low
  - Little existing transmission infrastructure
  - Few local resources (e.g. storage and ramping generation) to manage intermittency
  - Lower renewable generation construction costs
  - Much higher generation capacity factors possible
  - ➢ *Latter two factors lead to lower $/MWh average cost*
- Rich resources outside of California in Western Electricity Coordinating Council (WECC)
  - Difficult to see how California can meet 33% RPS goals at least cost without access to these resources

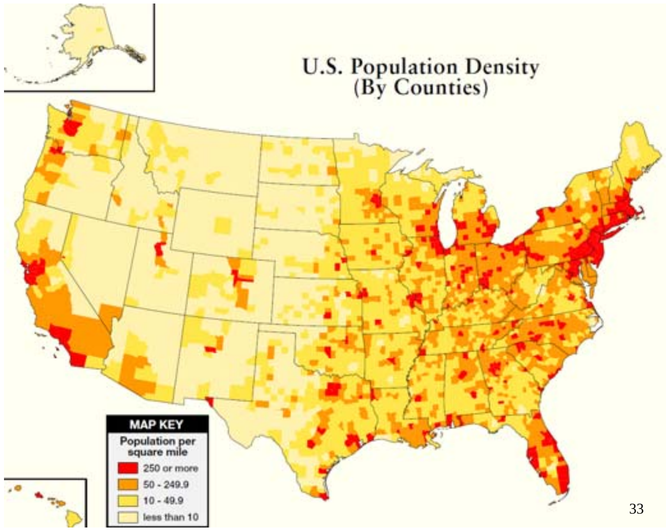
⇒ *Significant expansions of interstate transmission capacity throughout WECC needed*

Wind Resources in US









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Regional Regulatory Barriers

- Transmission expansion across state boundaries even more difficult than within California
  - Federal government does not have siting authority that it has for natural gas pipelines
- Energy Policy Act of 2005 gave Federal Energy Regulatory Commission (FERC) authority to designate strategic transmission corridors and order transmission lines to be built
  - Palo Verde/Devers 2 line proposed by Southern California Edison was a test case for this authority
- Need for renewable energy supply to major load centers strongly argues for regional transmission planning process
  - At least at Western and Eastern Interconnection levels

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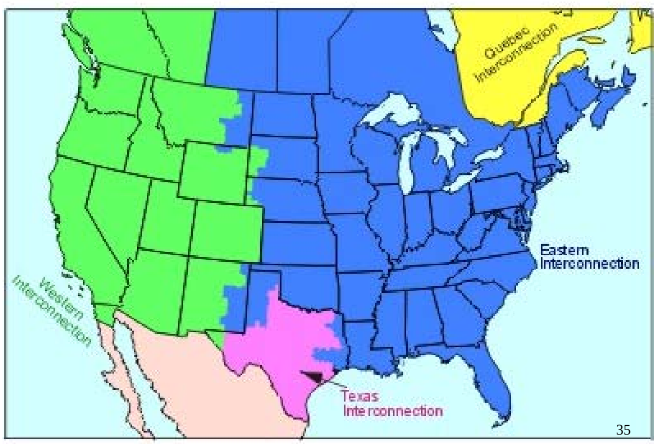
Electricity Interconnections



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PESD Research

- Quantifying benefits of expansions in wholesale market regime with renewable energy goals
  - Measuring market competitiveness benefits
  - Transmission as insurance against extreme events
    - Measure expected benefits of upgrade, rather than benefits of upgrade under expected conditions
  - Recognize benefits of forward-looking transmission planning that anticipates, rather than follows generation investments
    - Benefits of ERCOT's Competitive Renewable Energy Zones
  - Quantify interconnection-wide benefits of upgrades

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PESD Research

- Design of interconnection-level institutions for planning and pricing
  - Develop common state-level process to quantify regional benefits of upgrades
  - Design coordinated state and regional decision-making process
    - Coordinate planning with cost-allocation and pricing process
  - Is national legislation needed, and if so, what kind?
  - Where at state-level should coordination take place?
- Learn from international experience
  - Alberta's transmission investment policy
  - The UK's challenge to interconnect Scottish Hydro and Wind
  - The Spanish experience with large-scale wind
  - The Australia experience with wind integration

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PESD Research

- Design of a national market for renewable energy credits (RECs)
  - Low carbon energy credits versus RECs
  - Ensuring local balancing services are available
  - Transmission expansions occur to allow interconnection
- Symmetric treatment of load and generation
  - Manage intermittency of greater renewable generation share at least cost
  - Unlock benefits of smart grid technologies
    - Make storage and load-shifting economic

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PESD Research

- Symmetric treatment of load and generation
  - Dynamic pricing experiments
  - Wolak, Frank (2010) "An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCentsDC Program," on web-site
  - Wolak, Frank (2006) "Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment," on web-site
  - Quantifying the benefits of spatial granularity in pricing to load
  - Wolak, Frank (2010) "Quantifying the Benefits of Spatial versus Temporal Granularity in Retail Electricity Pricing," on web-site
  - Realizing benefits of automated response technologies
    - Smart real-time load-shifting in response to real-time prices
  - Reducing regulatory barriers to dynamic pricing
    - Increasing salience of electricity consumption
      - How actions translate into energy expenditures

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Conclusions

- Changes in industry structure in past 15 years dramatically changed paradigm for
  - Evaluating benefits of transmission expansions
    - Wholesale markets currently serve most major US load centers
  - Desire to significantly increase share of renewable energy
    - Resources must be produced where they exist (different from fossil fuel and nuclear power)
- National Renewable Energy Credit (REC) market ensures least-cost deployment of renewable resources
- Symmetric treatment of load and generation maximizes consumer benefits of smart technologies
  - Makes day-ahead dynamic pricing, storage and automated load shifting technologies financially viable
  - No customer needs to pay this price for any consumption, only face it as a default price, just like in all other markets
  - Electricity consumption similar to cell phone model
    - Purchase total monthly minutes at fixed price in advance
    - Real-time price per minute for consumption above total monthly minutes
    - Rollover of unused minutes similar to selling unconsumed contract quantity in day-ahead or real-time market

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For more information:
http://pesd.stanford.edu

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Economic Research at PESD

John Anderson
PhD Candidate in Economics
& PESD Graduate Researcher

- One of PESD's core competencies: Use of economic theory and empirical methods to inform energy policy.
- Important issue in energy policy: How should public funds be used to support renewable energy technologies?

- Often argued that public support for renewables results in cost reductions that will ultimately make renewables cost-competitive with conventional technologies.
- But, why not just let private sector make investments that lead to reductions in the cost of renewable technologies?

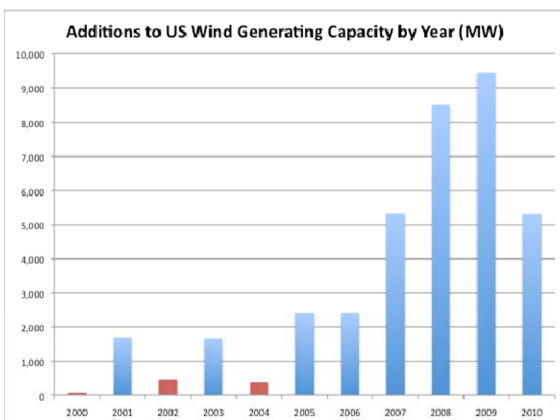
- One answer is **knowledge spillovers:** If private firms can't fully capture the cost reductions their investments generate, they will under-invest in cost-reducing technologies and processes.

- Public funding can help to "internalize" this positive **externality** – e.g. basic R&D support.

- In US, public funds are also used to subsidize deployment of renewable generating capacity.

- **Production Tax Credit** (PTC): per kWh tax credit for electricity generated from qualifying renewable resources.

- PTC outlays totaled $690 million in FY 2007 (97% to wind).



- Is the PTC a cost-effective means of promoting wind generating capacity?

- Do knowledge spillovers take place in the *installation* of wind generating capacity?

- My research finds little empirical evidence that costs decrease with accumulated experience installing wind capacity – i.e. little evidence of "learning-by-doing".

- Results suggest the PTC is *not* the most cost-effective means of supporting the development of wind generation in the US.
- Scarce public funds perhaps better spent on early-stage R&D in order to exploit spillover effects.

- Sign up for PESD eNewsletter:
  pesd.stanford.edu
- Enroll in GSBGEN 336: "Business Models for Sustainable Energy"