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Assessment of the Full Cost of Electricity (FCe^{-})

A multi-disciplinary collaborative project across the campus of the University of Texas at Austin

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Defining the Full Cost of Electricity

- Many Components Define the Full Cost of Electricity
  - Lost in Public and Private Discussions are the Linkages among the Cost Components
- The study will be multi-disciplinary in nature and synthesize analysis and perspective from all applicable disciplines and schools of thought and perspective.

Power Plant

- Capital (CAPEX)
  - Financing (per plant-specific risks)
  - Land lease
- Operation (OPEX)
  - Fuel
  - Labor
  - Maintenance
- Fuel price hedging
  - Handling risk and uncertainty
- Taxes & Subsidies
  - Greenhouse gas policy
  - Renewable policies
  - Pilot and demonstration projects (e.g. CO_2 capture)

Facilitating Infrastructure

- Cost of connectivity
  - Transmission and Distribution
  - Microgrids
- Storage or firming power for intermittency
- Smart Grid
  - Customer level control of home
  - Utility & ISO level control of grid and dispatch
- Energy Efficiency of End-Use
- Independent System Operator (ISO) operations
  - Ancillary services
  - Market design
    - Energy-only vs. Capacity Markets
    - Regulated utilities

Environmental & Life Cycle

- Water
- Land
- Health impacts from pollutants (NOx, SOx, Hg, Particulate Matter)
- Greenhouse Gases (CO_2, CH_4, etc.)
  - Federal regulation
  - State/regional regulation
- Waste and recycling
  - Spent nuclear fuel
  - Coal ash
  - Decommissioning
- Biodiversity (from land, water, air impacts)

UT-Austin Experts Dedicated to Project

Project Management & Research

James Dyer
Project Lead
Professor, McCombs School of Business

Fred Beach
Assistant Director (Policy Studies), Energy Institute

Carey King
Assistant Director, Energy Institute

John C. Butler,
Clinical Assoc. Professor, McCombs Business School

- Energy Finance
- Decision Analysis

Dale Klein
Associate Director, Energy Institute

- Energy Security
- Nuclear power

Roger Duncan
Research Fellow, Energy Institute

- Distributed Generation
- New utility business models

Core Research Team

Ross Baldick
Professor, Electrical & Computer Engineering

- Electric grid market operation
- Transmission and distribution
- Wind integration

Surya Santoso
Professor, Electrical & Computer Engineering

- PV integration, Distribution, and Storage
- Intermittency

Robert Hebner
Director, Center for Electromechanics

- Transmission, Distribution, Metering, and microgrids
- Stranded electric grid assets

David Adelman,
Professor, Law

- Health impacts from air emissions
- Regulatory and permitting costs

David Spence
Professor, McCombs Business/Law School

- Legal aspects of valuation of externalities and hedging
- EPA regulatory process

Sheila Olmstead
Assoc. Professor, School of Public Policy

- Valuation of environmental externalities

Melinda Taylor
Professor, Law

- Arbitration
- Energy and environmental law

Erich Schneider,
Associate Professor, Mechanical Engineering

- Nuclear power

Why This Work Is Important

Key Points

• The Problem

Focused studies may model "their solution" without simultaneously considering other alternatives, and may not consider the "full costs" of these solutions

• The Solution/Goal

Inform public debate and the policy process with ***quantitative, transparent, comprehensive and objective analysis***

- The Problem
  - One person's cost is another person's benefit
  - No quantitative structure *simultaneously* combines *all* cost information
  - Many economic studies are not transparent to lay person

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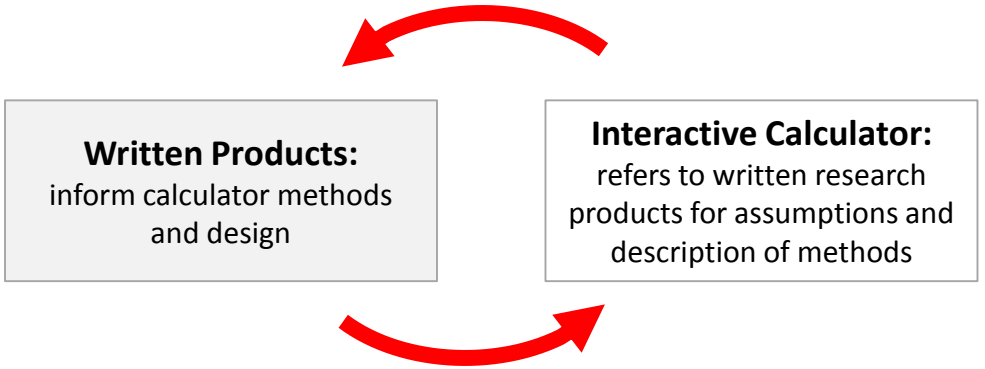
Work Products from FCe⁻ Study: Written Reports and Interactive Calculator

Key Points

- Project coordinated through Energy Institute
- Work products cover multiple audiences using tailored level of detail
- Written and interactive products reinforce and refer to each other
- Interactive product creates a 'living resource' to invite users to participate

- UT Energy Institute coordinates project across campus
  - Providing value by integrating perspectives across campus that otherwise would not occur
- **Core written products**
  - Phase 1: 'hard costs' and externalities for electricity
  - Phase 2: forward-looking projections of costs
  - Final Comprehensive Report
- **Interactive online calculator**
  - A "go to" tool for interested persons to compare electricity options



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The Electric Grid

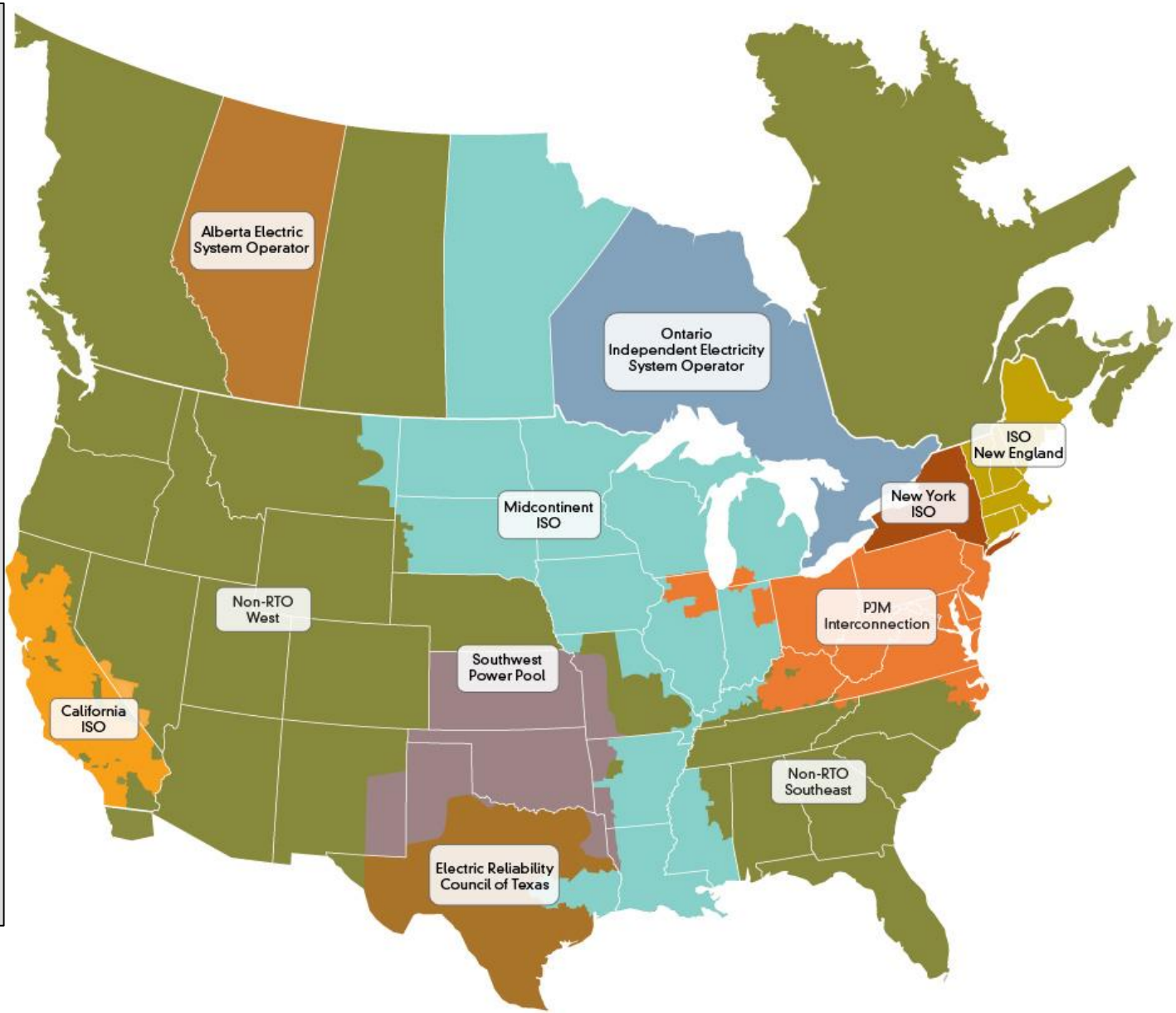
Grid Operation

Power markets

Least-cost Dispatch Rule

Generation Mix (2013):

- Coal – 39%
- Natural gas – 27%
- Nuclear – 19%
- Hydro – 7%
- Wind – 4%
- Solar - <1%



Potential Externalities: Generation Phase (Incomplete)

Generator Type	Air	Water	Solid waste	Other
Coal	PM, SO2, NOx, Hg, CO2	Heat Water consumption Discharges from ash storage, ... Etc.	Ash disposal ... Etc.	
Natural Gas	NOx, CO2 ... Etc.	Heat Water consumption		
Nuclear		Heat Water consumption	High-level Nuclear Waste	
Hydropower		Changes to stream ecology Fish migration Heat ... Etc.		Aesthetic
Wind				Bird/Bat mortality Aesthetic
Solar		Water consumption		Land use Bird mortality (CSP)

EPA's "War on Coal"

Air Pollution:

- PM standard
- SO2 standard
- Ozone standard

- Cross-State Air Pollution Rule
- Mercury Rule
- Greenhouse Gas (Proposed) Rules

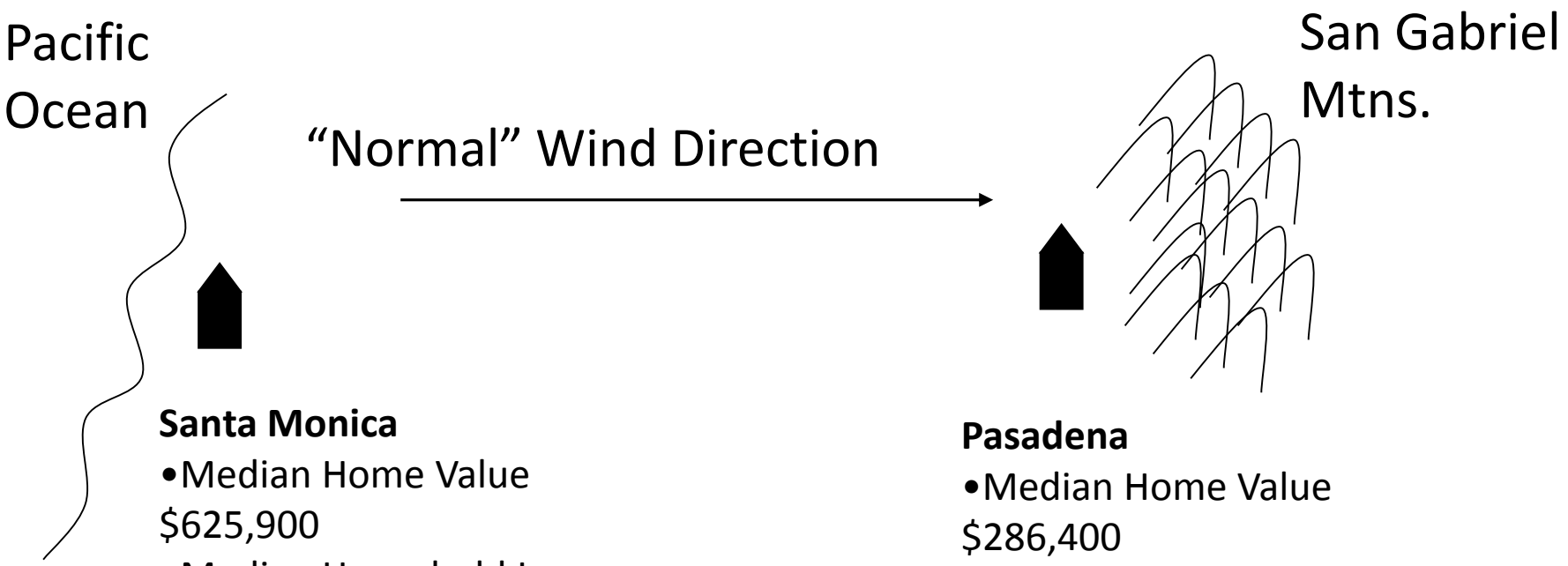
Other Regulation:

- Cooling Water Rule
- Coal Ash Rule
- Mining Rules

Economic methods for monetizing environmental amenities/disamenities

	Revealed Preference	***Stated Preference***
Explicit prices/markets	•Market prices •Simulated markets	•Contingent valuation
Implicit prices/markets	•Travel cost •Hedonic property values •Hedonic wage •Avoidance expenditures •Derived demand for options	

Valuing property value damages



Santa Monica
- Median Home Value $625,900
- Median Household Income $50,714
- 1 day above state ozone standard in 2001

Pasadena
- Median Home Value $286,400
- Median Household Income $46,012
- 28 days above state ozone standard in 2001

- Estimate the effect of air quality (e.g., smog in LA) on home prices, holding all else constant.

Valuing changes in mortality risk

- Wages provide a "footprint" in labor markets of compensation for mortality risk.
  - Observe wages for many jobs.
  - Wages are a function of many things, including risk premiums.
  - Risk premium: holding all else equal, environmentally inferior jobs command a higher wage.

- These risk premiums, estimated statistically from wage data, are used in regulations to monetize the value of avoided deaths (highway safety, workplace safety, ambient pollution control).

- EPA uses ~ $7 million (average of 21 labor market studies, plus 5 others) as the "value of a statistical life" in regulatory standard-setting.

Example: monetizing damages from U.S. air pollution

TABLE 1—MARGINAL DAMAGES OF EMISSIONS BY QUANTILE ($/TON/YEAR)

Pollutant	1st percent	25th percent	50th percent	75th percent	99th percent	99.9th percent	$E[MD]$
$PM_{2.5}$	250	700	1,170	1,970	12,400	41,770	3,220
PM_{10}	60	120	170	280	1,960	6,550	450
NOx	20	180	250	370	1,100	1,780	260
NH_3	100	300	900	2,000	20,620	59,450	2,520
VOC	40	120	180	280	1,370	4,540	730
SO_2	220	550	970	1,300	4,130	10,860	1,310

Note: Final column is the expected marginal damage of emissions for each pollutant.

- Muller, Nicholas Z., and Robert Mendelsohn. 2009. Efficient Pollution Regulation: Getting the Prices Right. *American Economic Review* 99(5): 1714-1739.
  - Included: Premature deaths, increased rates of illness, impaired visibility, depreciation of man-made materials, reduced recreation services, lost timber yields, and decreased agriculture harvests
  - Human health-related damages (deaths, illness) represent ~95 percent of these damage estimates.

Thank You

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