20 Cents to 10 Cents

Economics of Offshore Wind Power

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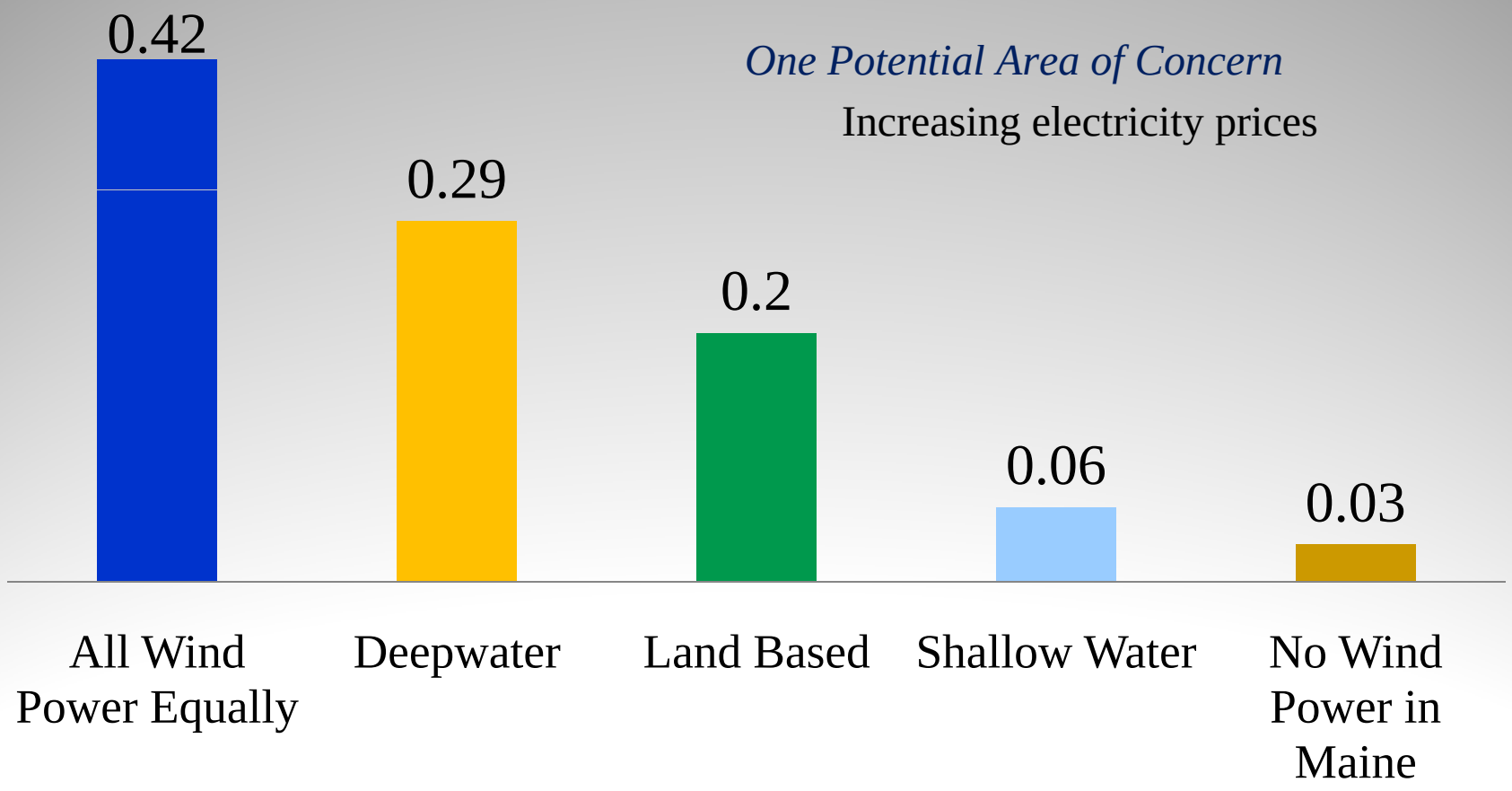
School of Economics

Modeling Stakeholder Acceptance of Solutions to Environmental Problems

Environmental Behavior Team
PI's :Mario Teisl, Shannon McCoy, Caroline Noblet
Maine Sustainability Solutions Initiative (MeSSI)

Mainers are supportive of wind energy development

What type of wind-power do Maine citizens support?



One Potential Area of Concern

Increasing electricity prices

Recent 20 Cents + Rate Approvals

- Block Island, RI
  - **8** x **3.6 MW** wind turbines = **28.8 MW**
  - **24.4** cents per kWh with 3.5% per year escalator
- Cape Wind, MA
  - **130** x **3.6 MW** wind turbines = **468 MW**
  - **18.7** cents per kWh with 3.5% per year escalator
  - **23** cents per kWh averaging in the escalation

Explaining 20 Cent Power

- Project capital costs ($ per kW)
- Annualized cost of capital ($ per kW per year)
  - Financing structure (debt/equity/tax partner)
  - Financial market conditions and rates
  - Risk adjusted return on equity
  - Tax rates and subsidies (ITC, MACRS)
- Marketing structure for off-take (PPA)
- Capacity factor (→ kWh per kW)
- O & M expense ($ per kWh)

Explaining 20 Cent Power

- Project capital costs : $5,500/kW (A.G. Coakley: over $2.5B)
- Annualized cost of capital ($ per kW per year)
  - $665/kW per year (relatively high financing costs)
- Marketing structure for off-take : PPA with utility
- Capacity factor : 37%
  - 0.37 x 8766 hours per year = 3,240 kWh per kW per year
- O & M expense ($ per kWh): $0.025 before tax
- Levelized cost of energy
  - Capital: $665/3,240 = $0.205 per kWh
  - Total: Capital + O&M = $0.224 per kWh

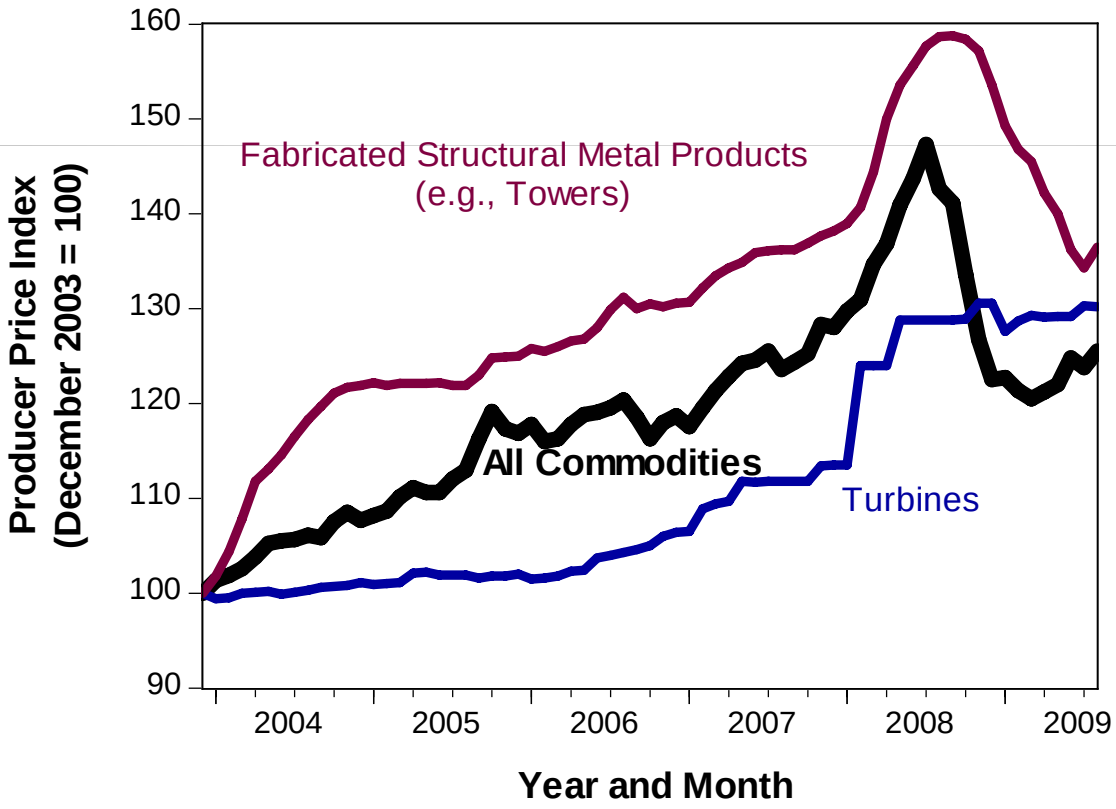
Note: All dollar figures are adjusted for inflation (2.5%) and expressed as constant 2010$.

Project Capital Costs

- Cape Wind: $5,500/kW
- EIA: $5,900/kW (revised Dec. 2010)
- Other research
  - $3,500/kW - $5,500/kW
    - steel , turbine, & commodity prices
    - supply chain development
    - learning effects (experience curve)

Steel, Turbine, Commodity Prices

Producer Price Indexes for Turbines and Fabricated Structural Metal



Source: U.S. Bureau of Labor Statistics

Conclusions on 20 Cent Electricity

- **20 cent+ electricity from offshore wind due to**
  - **High project capital costs**
  - **High financing/commodity costs (risk, recent world financial/commodity conditions)**
  - **Immature industry (learning and supply chain)**
- **Subsidies & PPA off-take arrangements have worked against even higher costs**
  - **30% ITC (or, 30% Section 1603 grant)**
  - **MACRS 5 year property**
  - **50% of ITC applied to reduce depreciable basis**
  - **PPA makes financing feasible**

Looking Ahead to 10 Cent Power

- Scaling the industry up
  - Effects of experience with building and deploying offshore wind turbines
    - For each doubling in cumulative installed capacity (kW)
      - 10 – 15 percent reduction in project capital costs (2010$/kW)
- Research on floating turbine technology, experience with onshore assembly & innovative deployment
  - contribute to progress on project capital costs
  - enable significant industry development in Maine
- As industry scales up and matures
  - Financing improves and contributes to lower cost

Looking Ahead to 10 Cent Power

- Scenario Assumptions
  - Start: $5,500/kW (2010$) in 2010
  - Learning rate 12% per doubling (20%-10%)
  - Doublings reflect Maine offshore buildout and projected world buildout rates
  - Financing improves with industry maturity
    - D/E 40/60 … 67/33
    - ROE after tax 18% … 10%
  - Extra tax incentives remain during 2010s and phase out during the 2020s going back to ITC = 10%, MACRS 15 year property Depreciable basis reduced by 100% of ITC
  - Capacity factor 45% (annual average)
    - Onshore = 32%, Cape Wind = 37%

Looking Ahead to 10 Cent Power

Period	Cumulative MW Installed	Doublings	$ / kW (2010$)	Subsidies	Finance	LCOE ** $/kWh (2010$)	
						12% 12%	20% 10%
2012-16	25 - 100	1	4,800 4,400	2011 levels	18% 40/60	0.19	 0.18
2017-20	500 – 1,000	3*	3,800 2,800	2011 levels	15% 40/60	0.14	 0.11
2021-25	3,000	4.5	3,100 2,400	ITC=10% Long DB	12% 50/50	0.12	 0.10
2026-30	5,000	5.7	2,600 2,100	MACRS 15 year	10% 67/33	0.10	 0.09

* Doubling from base of 100MW

**Learning rates for 2012-20 (12% and 20%) / learning rates for 2021-30 (12% and 10%)

Looking Ahead to 10 Cent Power

- **DOE Preliminary Targets for Offshore Wind Power (September 2010)**
  - **13 cents / kWh by 2020**
  - **7 – 9 cents / kWh by 2030**
- **Deepwater is doubling scale of its Rhode Island Sound project to 1,000 MW**
  - **Suggesting that the larger scale will enable it to achieve cost / kWh in the "mid-teens" ($0.15/kWh)**
  - **Need project capital cost of $4,000/kW not $5,000**

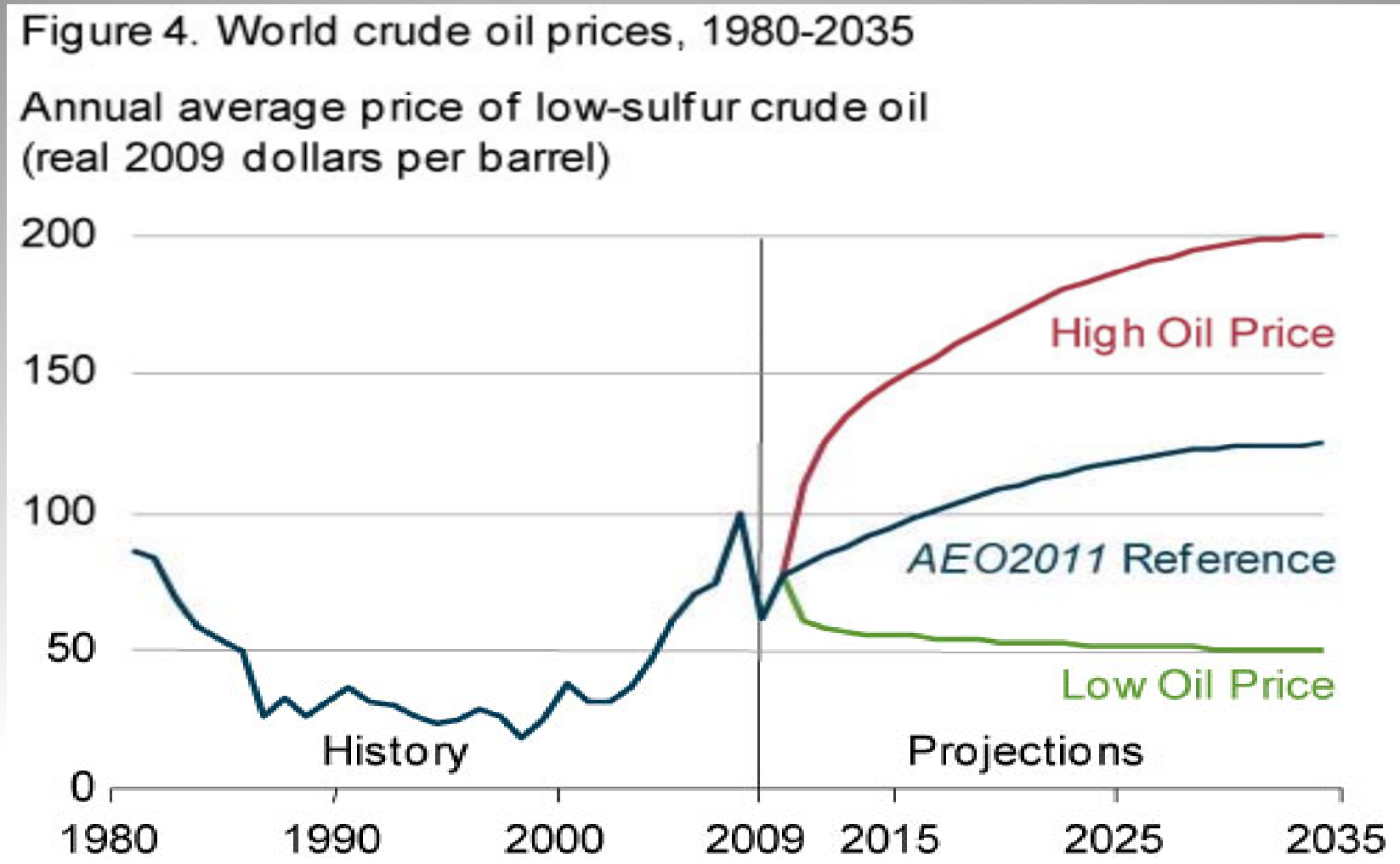
As Scale Up Proceeds

- Higher than market electricity rates will be blended into customer base
  - RPS/Environmental Goals
  - Hedge Energy Price Volatility
  - Local Economic Development
- Policy to limit rate impacts
  - MDPU: cap on IRR = 10.75% to avoid windfall profits
  - MPUC: cap on customer rate impacts (0.145 cents/kWh)
- In 2020s subsidies can likely be phased out
- During 2010s support for research, development, and demonstration as well as local supply chain scale up are important

COST COMPARISONS

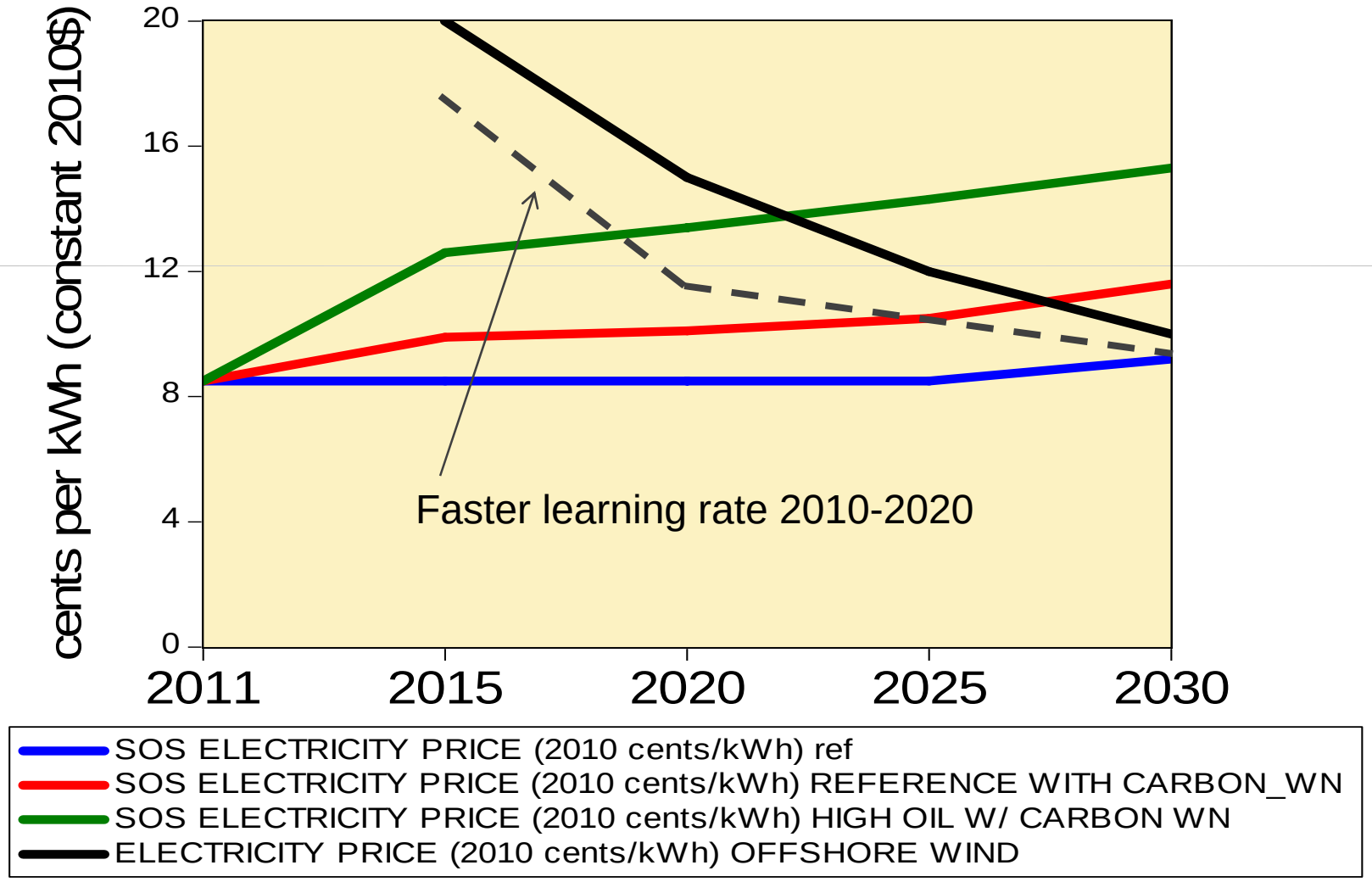
- Electricity Generation Alternative Scenarios
  - Offshore wind
  - Natural gas combined cycle turbines
    - EIA reference case (*AEO 2011*, Early Release)
    - EIA high oil price case (*AEO 2011*, Early Release)
    - EIA reference case with Nordhaus carbon charges
    - EIA high oil price case with Nordhaus carbon charges
  - Nordhaus carbon charges per ton CO_2 (per ton C)
    - 2015 $16 ($59)
    - 2020 $20 ($73)
    - 2025 $26 ($95)
    - 2030 $33 ($121)

EIA High Oil Price Case



Source: EIA, *Annual Energy Outlook 2011* (Early Release)

ALTERNATIVE ELECTRICITY PRICE PATHS



Key Points

- Incentives are critical during 2010s
  - Industry development ->
    Learning -> cost ⬇
  - Industry matures ->
    financing + supply chain improve -> cost ⬇
- Carbon charges on fossil fuels
  - Gets environmental costs put into market
  - Levels the “playing field” for
    - Wind energy market development
    - Development of other renewables
- Offshore wind becomes competitive in 2020s with correct policies

Key Policies

- Current federal incentives during 2010s
  - RD&D
  - ITC (section 1603), MACRS 5 year
- Carbon pricing during 2010s and beyond
  - (alternative: national / state RPS-E)
- State/local policies
  - Long term PPAs – tied to planned buildout
    - blending into rate base with caps
    - challenge during 2010s
  - Facilitate supply chain / workforce developments
  - Green SOS alternative

Important Benefits

- Long term wind power development and PPAs
  - Stabilize electricity prices (energy security)
- Reliance primarily on natural gas fired generation
  - Does not stabilize electricity prices
  - Natural gas price is coupled to oil price
    - Will fluctuate with oil prices
- Wind energy buildout creates significant
  - Local economic development
  - Jobs (Up to 15,000 with supply chain maximized)
- Significant environmental benefits with renewables
  - Reduction of CO2 and other fossil fuel emissions

20 Cent to 10 Cent Power

- Current electricity costs for offshore wind reflect
  - High project capital costs
  - Relatively high financing costs
    - Risk
    - Young industry
    - Recovering financial/commodity sector conditions
- Future electricity costs for offshore wind reflect
  - Lower project capital costs
    - RD&D and learning effects as industry scales up
  - Lower finance costs
    - Lower risk as industry scales up and matures

20 Cent to 10 Cent Power

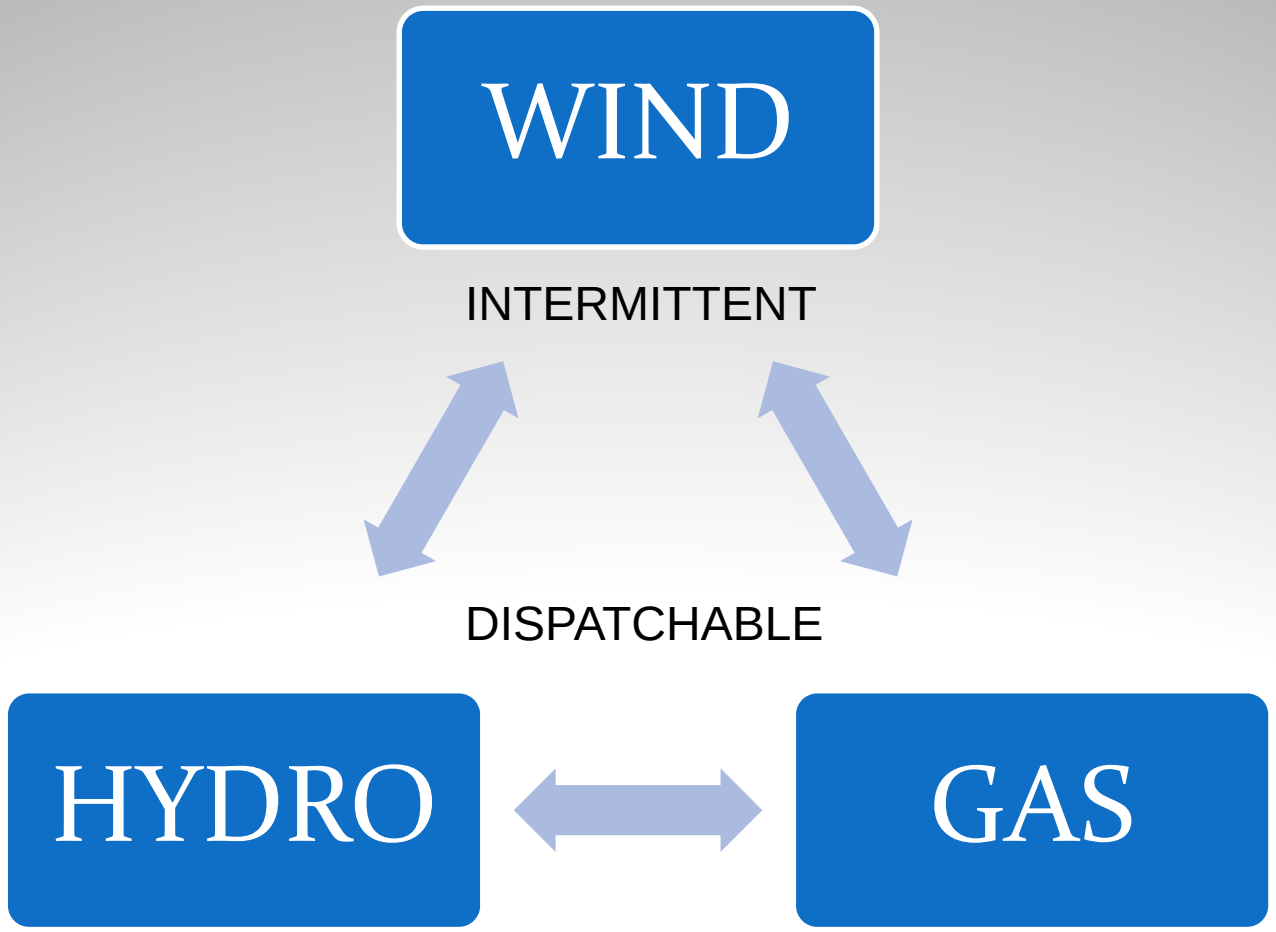
- Offshore wind power future
  - competitive price
  - clean energy
  - energy security/more price stability
  - local economic development
- Long term investment view (benefits grow in out years)
- Policies that facilitate
  - RD&D
  - Building of turbines and farms
    - to realize learning effects
    - to mature the industry and realize financing improvements
  - Supply chain and workforce development

ENERGY PORTFOLIO IDEA

ECONOMIC DEVELOPMENT

COMPETITIVE COST – ENERGY SECURITY

ENVIRONMENTAL BENEFITS



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"Maine Offshore Wind Energy: Cost Estimates"
(UNDER REVISION)
"Maine Offshore Wind Energy: Comparative Cost Analysis"
(UNDER REVISION)
(February 2010— UNDER REVISION)
"Maine Offshore Wind Energy: Wind Resources, Technologies, and Energy Production"
(SUBJECT TO REVISION)

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