

Technical Options and Challenges in the Energy Transition

Paul Wilson
Engineering Physics

*Aspiration and Reality
in the Energy Challenge
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Energy Infrastructure Will Transition to Meet Various Goals

- **Environmental**
 - Global climate change (CO₂)
 - Air quality (NO_x, SO₂)
 - Water quality (Hg)
 - Spent Nuclear Fuel
 - Land-use
 - View-shed
- **Supply security**
 - Reduce foreign imports
 - Reduce out-of-state imports
- **Economics**
 - Maintain affordability & improve competitiveness
 - Reduce price volatility
 - Create jobs

Conservation & Energy Efficiency are Always the First Step

- Simply use less primary energy
- Reduce the demand for end-use energy
 - But... increased 0.19% per year (2000-2008)[‡]
- Improve energy conversion, wasting less energy in the process
 - But... primary energy consumption rose 0.35%/yr[‡]
- Electrification
 - Electricity demand grew 0.98% per year[‡]
 - Electricity share grew 0.79% per year[‡]

[‡]2009 Wisconsin Energy Statistics, State of Wisconsin Office of Energy Independence

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Wisconsin's Energy Future

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Big Increases in Some Renewable Technologies since 2000

- Wind: 3-5x increase
- Biogas: 2x increase
- Biomass: 3x increase
- Total renewable generation up only 52%
 - 21% reduction in hydro
- Fossil fuel switching
 - Coal → Petroleum
 - Natural gas growth!! 2.4x increase



Low-Emission Technology Provided 24% of WI 2008 Domestic Electricity Generation[‡]

- Wind 0.38%
- Biomass 1.4 %
- Biogas 0.65%
- Hydro 2.6 %
- Nuclear 19. %

Unchanged since 2000!



- Low-emission provided 12.5% of primary energy (4.5% renewable, 8.0% nuclear)
 - Increased from 10.5% in 2000

[‡]2009 Wisconsin Energy Statistics, State of Wisconsin Office of Energy Independence



Can We Afford to Ignore Any Low Emission Technology?

- Demand management
 - Reduce primary energy consumption
- Hydro is essentially capped
- Bio-fuels (biomass, biogas)
 - 10x increase \Rightarrow 20% (‡)
- Wind generation
 - 10x increase \Rightarrow 3.8% (‡)
- Nuclear generation
 - 1 new reactor \Rightarrow 34% (‡)

(‡) assuming no demand growth

Can We Achieve These Deployments?

- Bio-fuels electric generation
 - Land-use concerns
 - Biomass supply
- Wind generation
 - Siting
- Nuclear generation
 - “Moratorium” in WI
 - 10 years to deployment



How Can Nuclear Energy Meet Various Goals

- Environmental
 - Global climate change (CO₂)
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- Supply security
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Spent Nuclear Fuel: An Active Demonstration of Stewardship

- Compact, Contained, Cared for
- Array of demonstrated long-term solutions
 - Improvement and efficiency

Technical Opportunities and Challenges: Understanding How It All Works Together

- Systems-based analysis
 - Technical interactions
 - Social impacts
 - Economic impacts



Paul Wilson
wilsonp@engr.wisc.edu

energy.wisc.edu