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# Looking Beyond the Targets

*Capacity Requirements to Achieving  
Large-Scale Greenhouse Gas Reductions  
in the United States and Beyond*

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*laboratory  
for energy  
and the  
environment*

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MIT Energy Initiative



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# US Targets and Beyond...

- Overview: US Policy and Legislative Landscape
  - Actors / Stakeholders
  - Making Laws in the US
  - **Climate and Related Legislation**
  - Domestic and International Dimensions
- Sustainable Energy Pathways
  - Technology Development, Deployment and Use
  - Substantial and Sustained Reductions
  - **A Three Part Strategy for Sustainable Energy**
  - What's Missing in the Climate Debate?
- Moving Beyond Mitigation?
  - Mitigation and Adaptation
  - **Climate and Sustainable Development**
  - Too Big an Emphasis on "Climate Change Mitigation?"



# US "Policy Landscape"

- Many, Many Actors...

- **The Federal Level**

- Executive Branch, Congress, Judicial Branch
- Legislation and Regulation

- **States and Regions**

- Many existing state targets
- Regional cap and trade systems (RGGI)

- **Cities and Towns**

- **Companies, NGOs & Individuals**

- Lobbyists for and against, etc.



- **Complex Legislative and Regulatory Processes**

- **Federal vs. State // Laws vs. Regulations**

- **House and Senate Legislation...**

- Conference Committees, Vetoes & Overrides

- **International Treaties** – Senate 2/3 Majority Approval





## Federal "Action"...

- House of Representatives: Waxman-Markey  
**ACES**: American Clean Energy and Security Act
  - Passed by House on 26 Jun'09, 219 to 212
- Senate: Kerry-Boxer  
**CEJAPA**: Clean Energy Jobs and American Power Act
  - Submitted, Hearings Imminent...
  - Supersedes Bingaman ACELA: *American Clean Energy Leadership Act* passed out of the Senate Energy and Natural Resources Committee on 17 June'09?
- Support from the White House
  - Continued positive comments from President Obama and Secretary of Energy, EPA and others bills
  - But, how international negotiations play into national legislation still very tricky



Obama at MIT  
23 Oct'09 © AP



# Ongoing Federal Legislation

- **H: Waxman-Markey & S: Kerry-Boxer  
GHG Reduction Targets**

- 2012 – 3% Reduction from 2005
- 2020 – 17% (H) or 20% (S) from 2005
- 2030 – 42% from 2005
- 2050 – 83% from 2005 (80% from 1990)



PEW CENTER

Global CLIMATE CHANGE

[www.pewclimate.org](http://www.pewclimate.org)

- » **Generally Matched Legislation..**

- **Cap and Trade System** – *Still a Lot of Details to Be Resolved*
  - Auctions vs. Allocation of Allowances/Permits
  - Banking & Offsets (Forestry & Agriculture; International vs. Domestic)
  - Reserve Prices - \$10 USD/ton, escalates at 5%/yr + inflation
  - Strategic Allowance Reserve/Market Stability Reserve
  - International Coordination/Participation, Anti-Leakage/Competition
- **Clean Energy Provisions**
  - Building Codes, Efficiency Standards, Renewable Elec. Std.
  - CCS, Nuclear, Nat.Gas, Transmission Investments, Biomass, Vehicle R&D, Public Transport, etc.
- **Impact/Adaptation Reporting, Land Use Change**



## US Targets and Beyond...

- How Do You Actually Do 80%?  
**"At Scale, in Time, and for All"**
- What Does 80% Really Mean?
  - > Is the "Magic of the Markets" enough?
  - > **When Does "Cap and Trade" become just a "Cap?"**
  - > What Has AGS Energy Pathways Research Told Us?
- **What's Missing? What's Not Being Discussed? Developed? Built?**
  - > Is a GHG Mitigation Approach Best?
  - > A Combined Strategy for both "Global Climate Change," and "Regional Sustainable Development"

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# Regional Energy Sustainability

- Designing for the Dynamics
  - » In Space & Time (GIST)
  - » "Nodes and Modes of Systems Operation"
- Policies: Moving Beyond Targets and Incentives
  - » Emissions Trading ( "Kyoto" and "Copenhagen" )
  - » Renewable Obligations – Feed-in Tariffs
  - » Biofuel Mandates, etc.
- What Information and Institutions Do We Need for "Fast Implementation?"

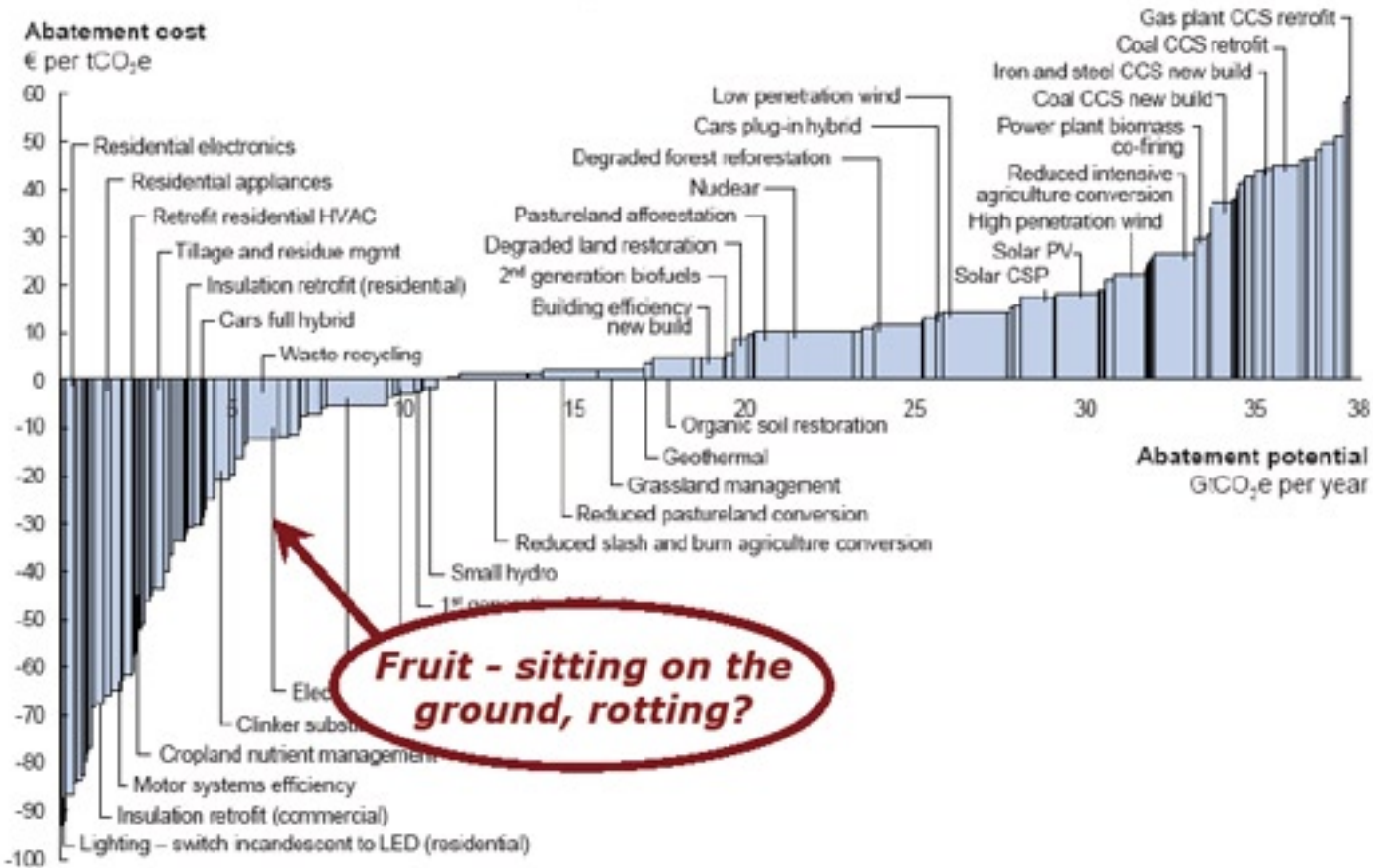




# "Clean Tech" - Low Hanging Fruit

- McKinsey "Pathways to a Low-Carbon Economy Ver.2 Global Greenhouse Gas Abatement Cost Curve" (Jan.'09)

Global GHG abatement cost curve beyond business-as-usual – 2030



## Four Classes

- Buildings and Appliances
- Vehicle Fuel Economy and Biofuels
- Industrial Energy Efficiency
- CO<sub>2</sub> Intensity of Power

## Four Questions

- Only CO<sub>2</sub> Cost Benefits?
- New Energy Technology Bias? (New vs. Retrofits)
- Substitution of Energy with Information
- Reliability/Variability

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO<sub>2</sub>e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.  
 Source: Global GHG Abatement Cost Curve v2.0





# At Scale, In Time, and For All

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- Recommendations for *Energy Importing Nations* to meet both *Climate Change and Energy Security* goals...

## » **Aggressive End-Use Efficiency**

- › Requires a detailed understanding of energy use patterns, to deploy the “three classes of energy efficiency.”

## » **Diversify Domestically**

- › Requires a detailed understanding of the size, temporal and spatial variability of energy sources and sinks.

## » **Modernize Energy Networks**

- › Requires a detailed understanding of the above and network thresholds and important infrastructure “nodes and modes”



# Energy/Emissions in Space/Time

- **Renewables *and* Efficiency**
- **Redefining “*Energy Efficiency*”**
  - » Energy **Conversion** Efficiency
    - Historically Synonymous with “Energy Efficiency”
    - Leading Example: Efficient Light Bulbs
  - » Energy **Utilization** Efficiency
    - The “Efficiency of turning things off”
    - Leading Example: Hybrid Automobiles
  - » **Integrated** Energy Efficiency
    - Look at “Two Birds/One Stone” **Energy Services**
    - Leading Example: Combined Heat and Power



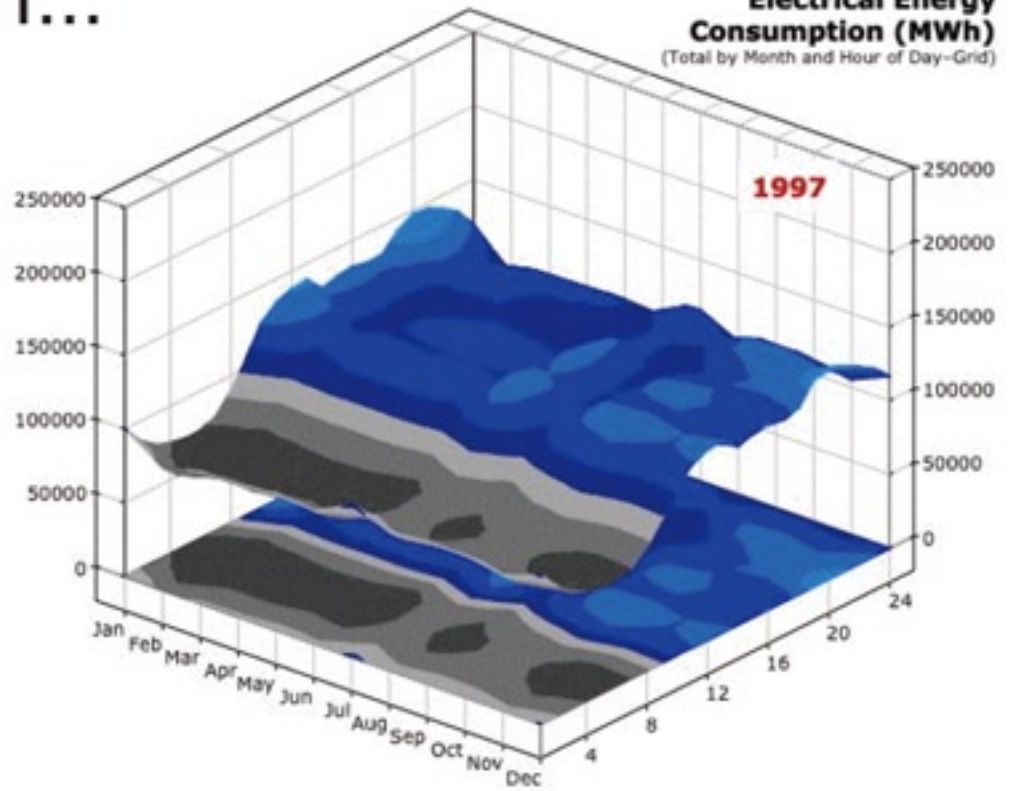


# Energy Demand Dynamics

- Where is End-Use Efficiency Most Beneficial?
- To Integrate With...
  - » Wind energy
  - » Solar
  - » Hydropower
  - » Biomass/Waste
  - » Ocean/Wave
  - » Storage (incl. H<sub>2</sub>)
  - » *Everything...*

**MIT** Portugal

**Electrical Energy Consumption (MWh)**  
(Total by Month and Hour of Day-Grid)

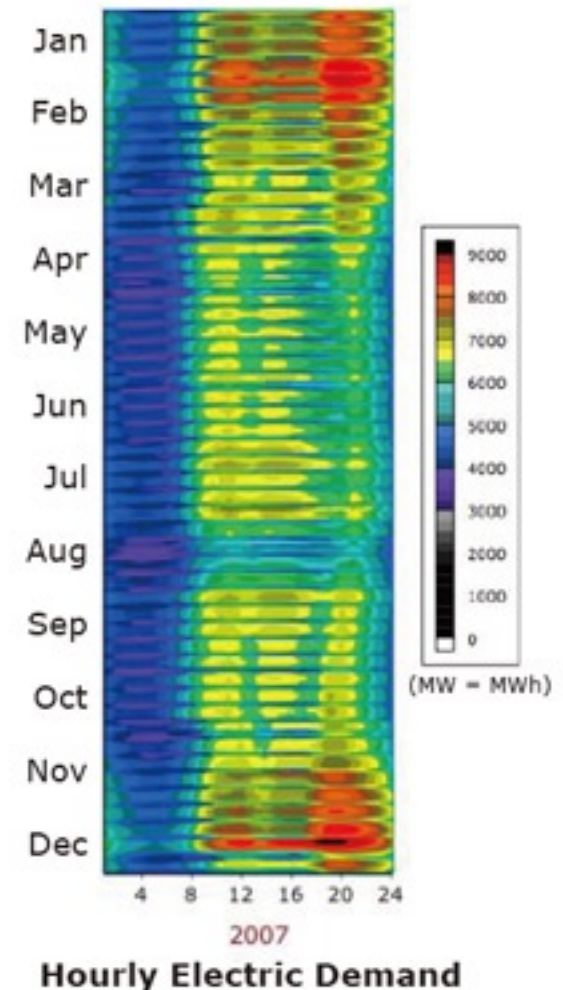
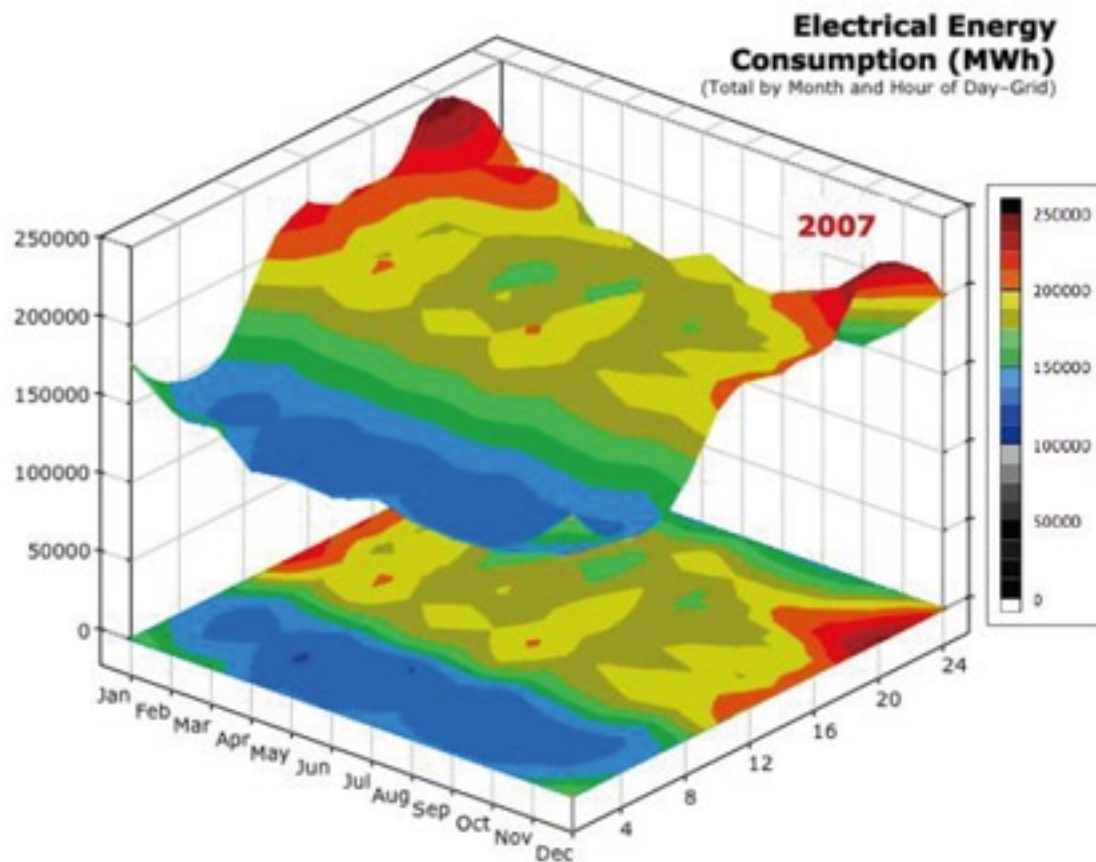


**Mainland Portugal Electricity Demand**  
(REN Data)



# Higher Resolution/Better Design

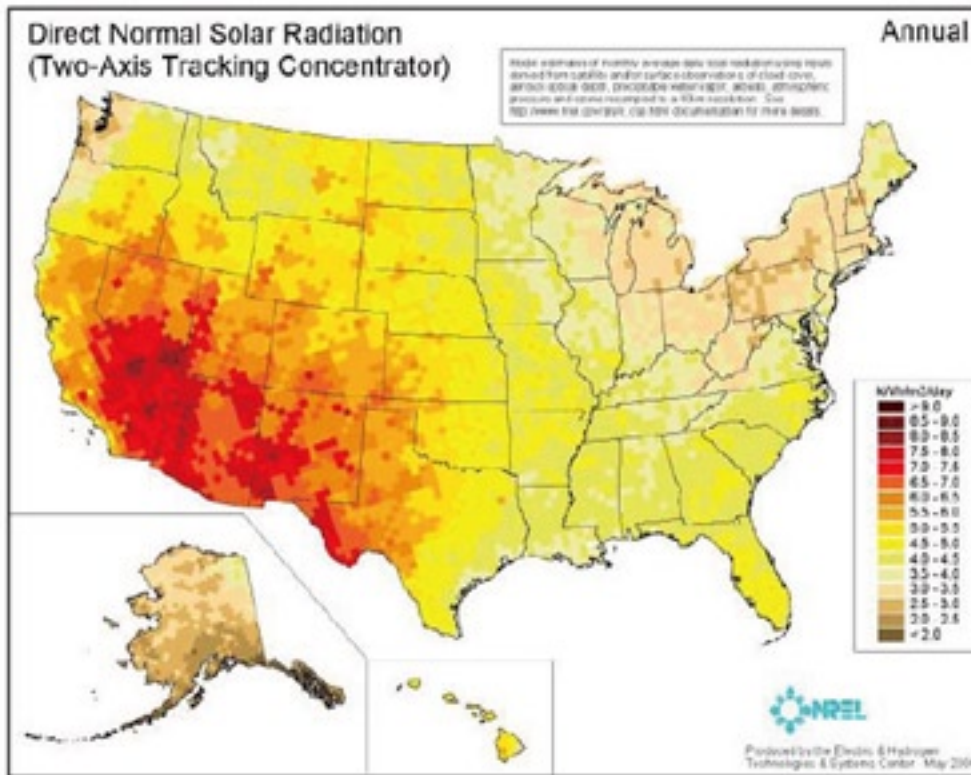
- Mainland Portugal Electricity Demand 2007 (REN)





# Large Scale Renewables... Solar

## Where and When is it Sunny? (Definitely more than just latitude)

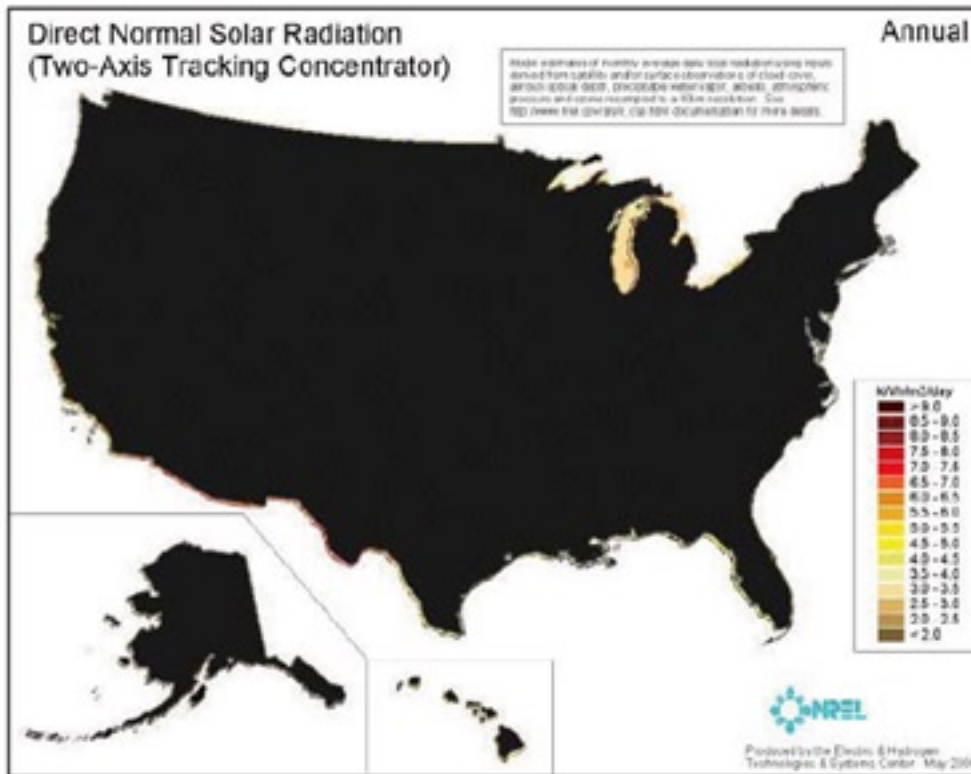




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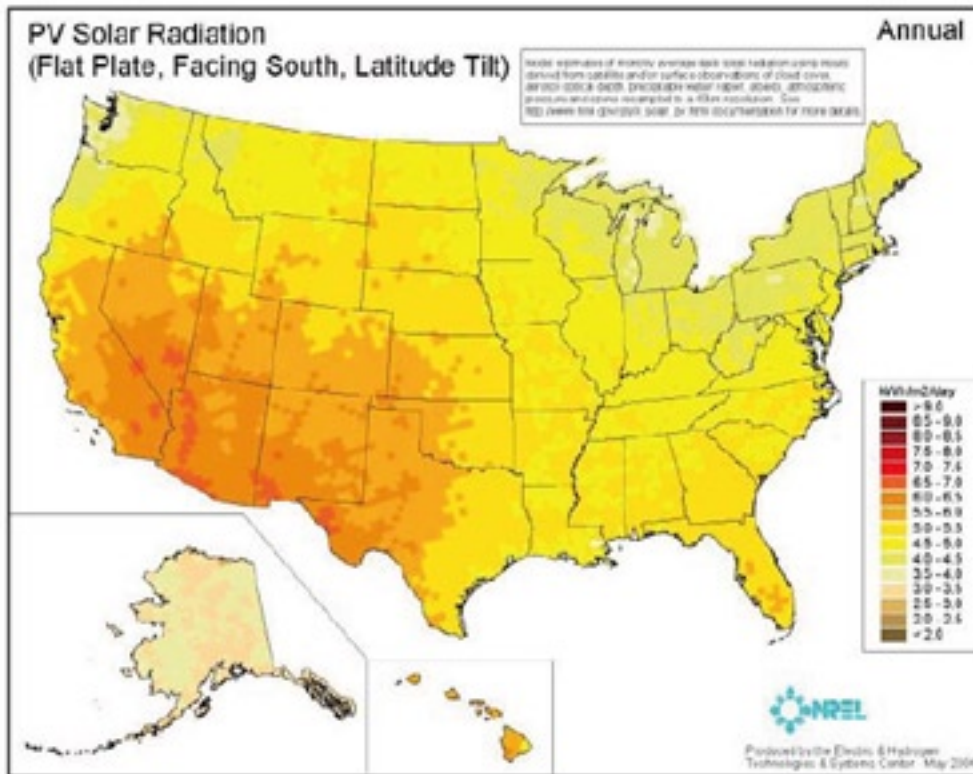




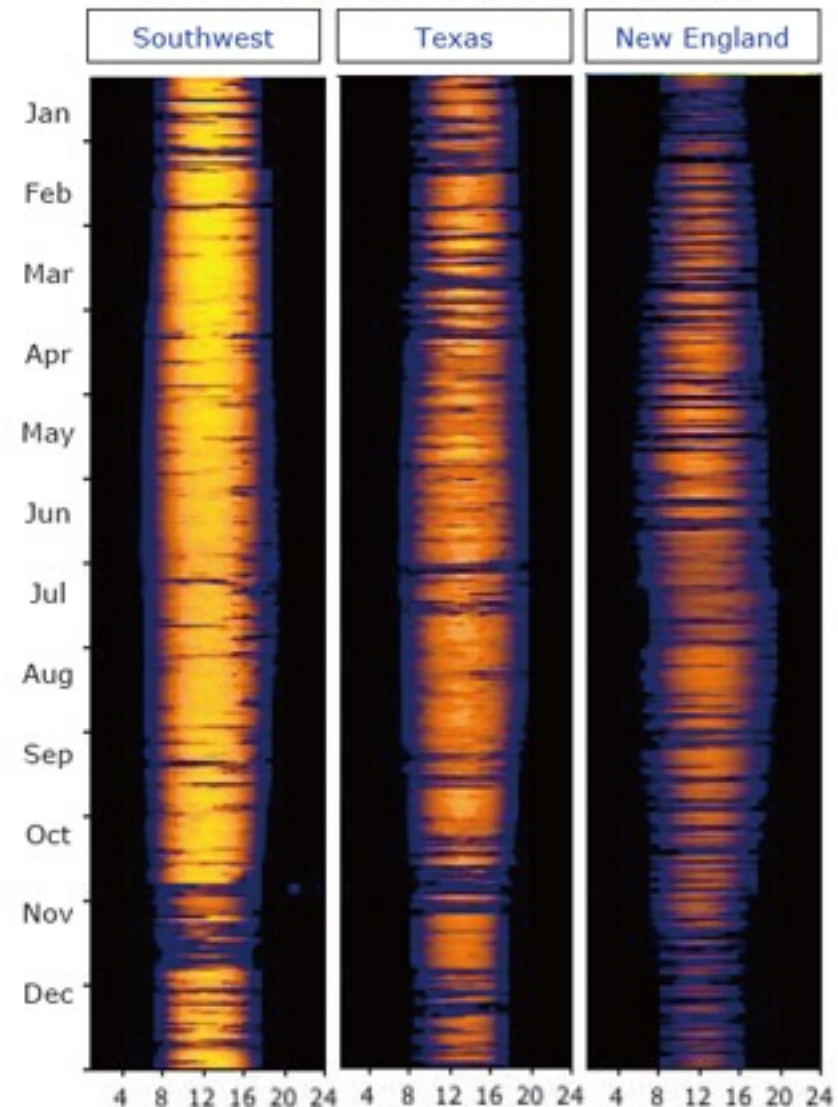
# Statistics Hide Details/Dynamics

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(Definitely more than just latitude)

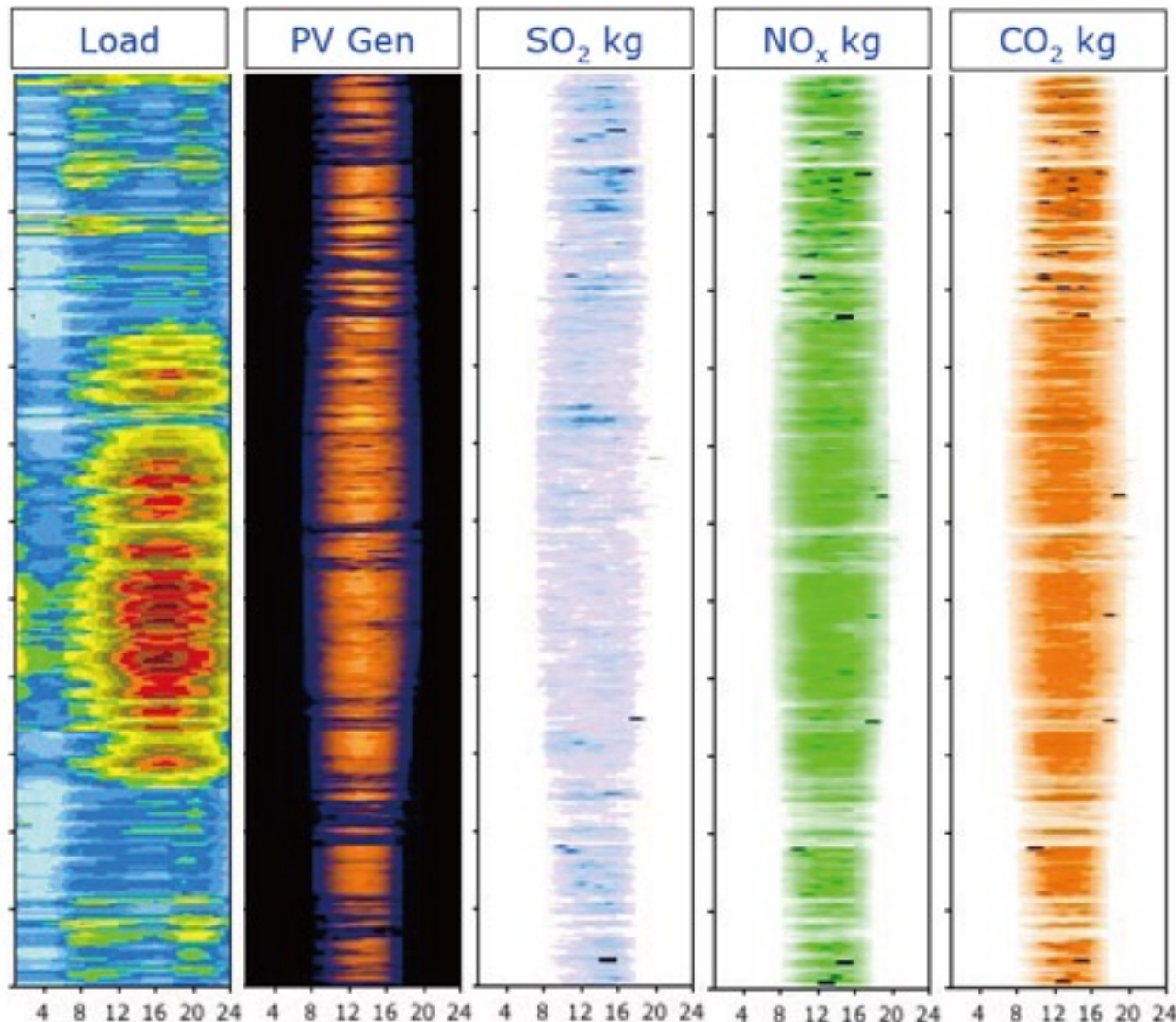


## Simulated PV System Generation (kWh/kW installed, 2002 hourly insolation)



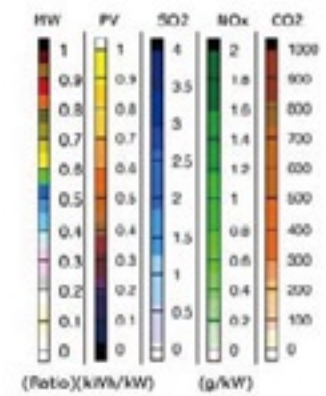


# Emissions Reductions from Solar - Texas Style



**Texas**  
(ERCT-2002)

- 365 days x 24 Hours
- Total Load/Elec. Demand
- PV Generation  
(**Monitored** Systems, normalized to 1 kW of installed PV capacity)
- + Avoided LSF fossil emissions from PV generation (kg per hour)

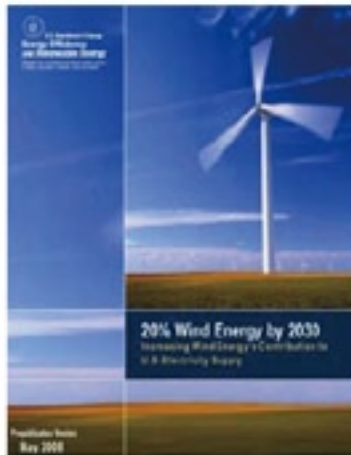






# Large Scale Renewables... Wind

- A "Smart Grid" for Long-Distance Wind



Wind Power Classification				
Wind Power Class	Resource Potential	Wind Power Density at 50 m, W/m <sup>2</sup>	Wind Speed* at 50 m, m/s	Wind Speed* at 50 m, mph
2	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.6
6	Excellent	500 - 600	7.5 - 8.0	16.6 - 17.9
8	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1400	8.8 - 11.1	19.7 - 24.8

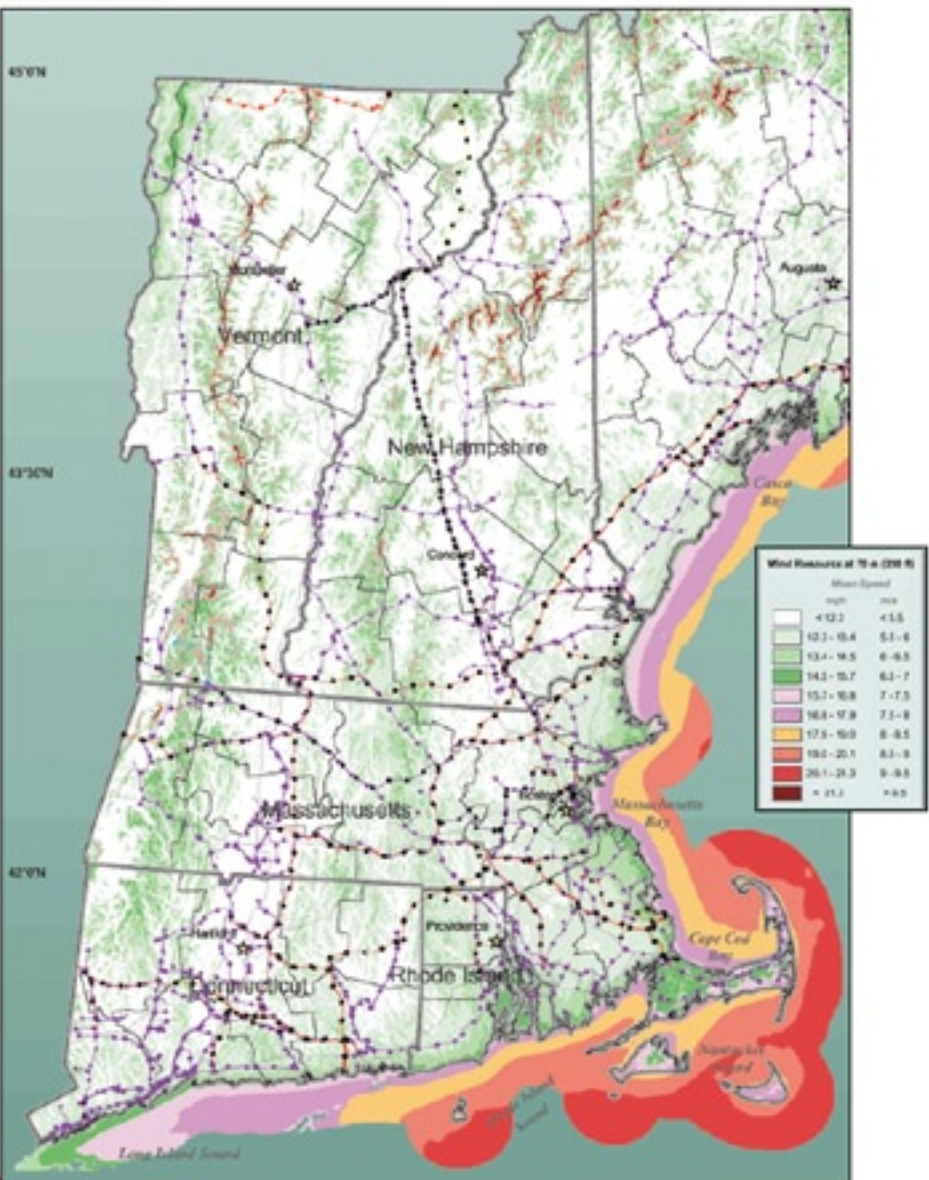
\* Wind speeds are based on a Weibull  $k$  value of 2.0

This map shows the wind resource data used by the WnDS model for the 20% Wind Scenario. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

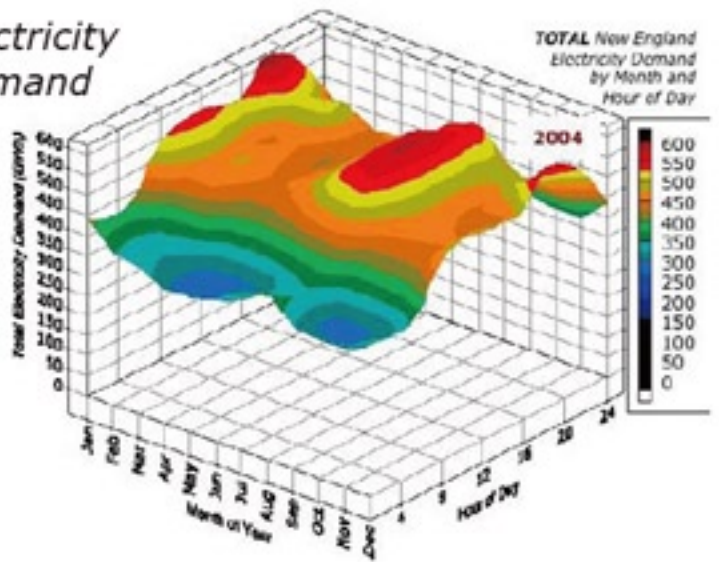




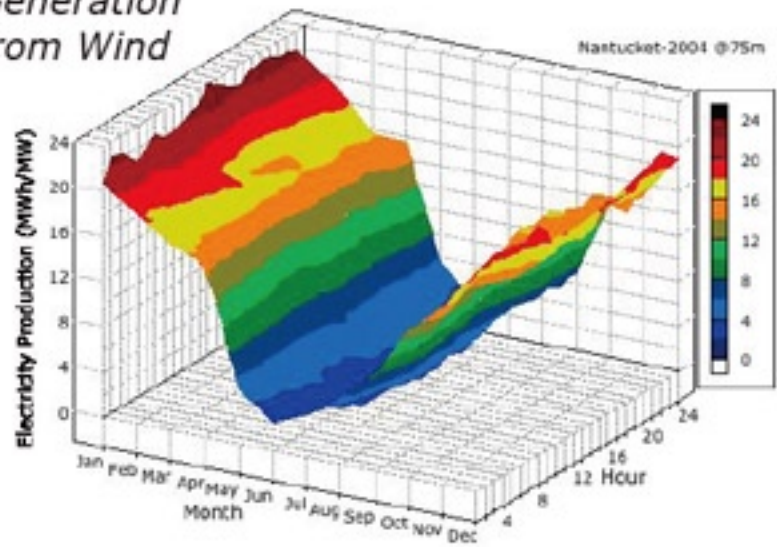
# Wind Integration: New England



Electricity Demand



Generation from Wind

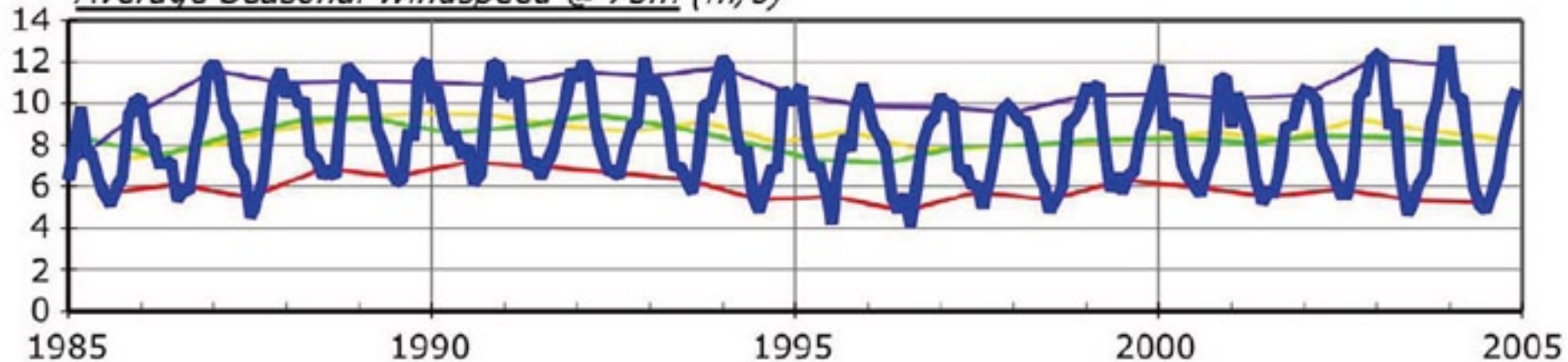




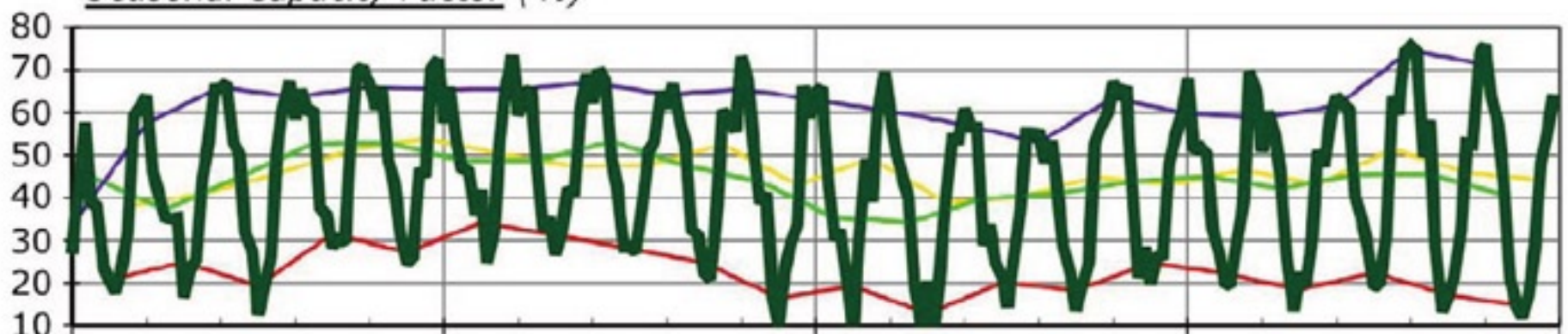
# Long-Term Variability in Wind...

- Nantucket (Sleigh Ride?)

Average Seasonal Windspeed @ 75m (m/s)



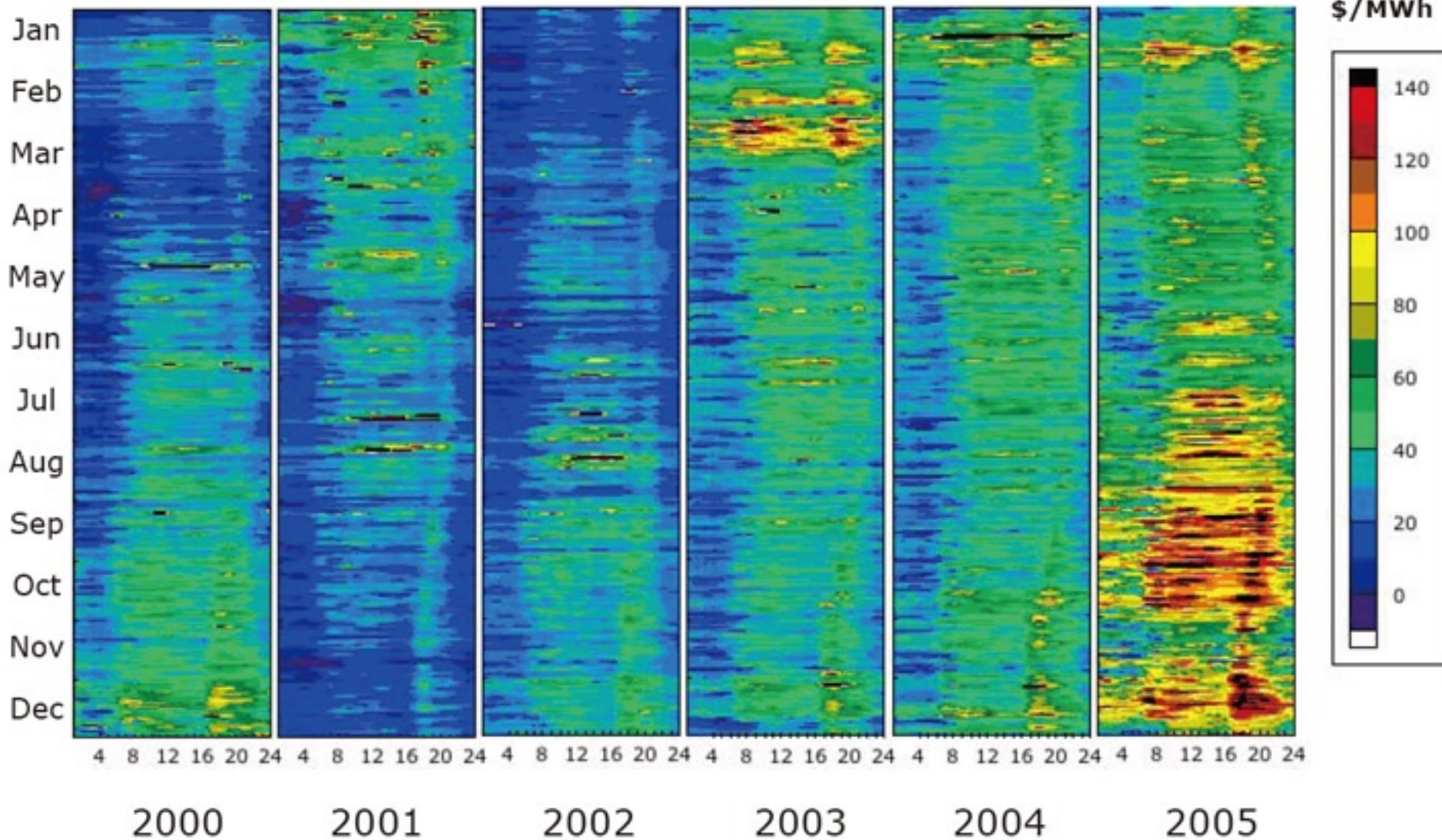
Seasonal Capacity Factor (%)





# Cost-Emissions Dynamics

Hourly Wholesale Electricity Price in New England (\$/MWh)





# Biofuels - Different Dynamics

- *Ethanol*

- » Which feedstock?  
(sugar, seed, plant)
- » Implicit feedstock variability  
/product stability issues
- » Thousands of assumptions  
regarding agricultural  
practices, biorefineries, etc.

- *Similar assumptions  
for Biodiesel*

- *New Challenges/Risks*

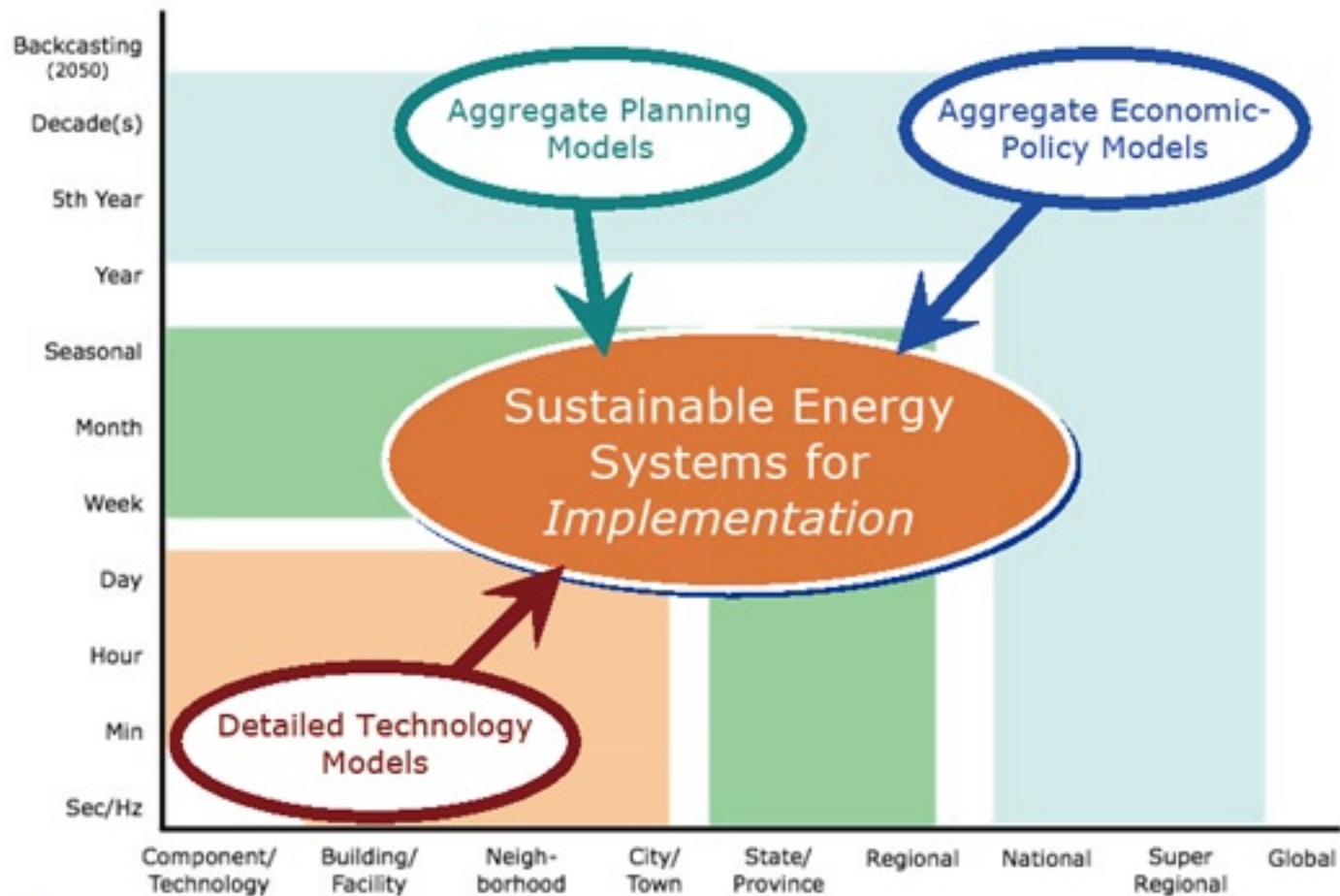
- » How sensitive performance  
as geography changes?
- » Broad societal risks from  
drought, floods, etc.





# Moving to Higher Resolutions

- Developing New Tools, Information and Institutions to "Act Locally"





# Regional Energy Sustainability

- “Climate” and Energy Security
- Substantial & Sustained Reductions
- Lots of Risks
  - Aging Infrastructures
  - Timely Investments, etc.
- Sustainability  $\neq$  Climate
- Pollution, Poverty, and Population
- Design for “Rapid, Large Scale Deployment”

BBC NEWS

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**Economy**

Page last updated at 21:31 GMT, Thursday, 26 June 2008 22:31 UK



**Crude oil at a fresh high of \$140 ~~\$40~~ ~~\$75~~ \$???**

The price of oil hits a fresh high of \$140 a barrel fuelling fears about inflation and the health of the global economy.

- Why is oil so expensive?
- Oil price up despite Saudi pledge
- Oil summit calls for supply boost

Current Climate Targets

"20% by 2020"

"80% by 2050"

"Cap and Trade"?



# Looking Beyond GHG Reductions

- “Climate” and Energy Security
- Substantial & Sustained Reductions
- Lots of Risks
  - Aging Infrastructures
  - Timely Investments, etc.
- Sustainability  $\neq$  Climate
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**BBC NEWS**

Page last updated at 11:53 GMT, Wednesday, 30 September 2009 12:53 UK

## \$100bn a year for climate safety

By Richard Black  
Environment correspondent, BBC News website

**Adapting to** impacts of climate change will cost \$75-100bn (£47-63bn) per year in the developing world from 2010, a World Bank study concludes.

The bank released preliminary findings from its new global study at the latest round of UN climate talks in Bangkok.

The figures assume that temperatures rise by 2C (3.6F) in the next 40 years.

How to finance adaptation, and how much money will be available, is a major theme in the talks that are supposed to produce a new global treaty this year.



African countries are likely to need help in adapting to drier conditions





# Conclusions and Insights

- **US Climate Debate and Legislation...**
  - Bills in the House and Senate Have Significant Targets
  - Domestic Cap & Trade + Incentives May Look Substantial, but Even If Passed May Have a "Poison Pill" Regarding International Participation (including Treaty Ratification)
- **Substantial & Sustained Reductions**
  - Aggressive End-Use Efficiency, Domestic Diversification, and Modernizing Energy Networks ALL Needed
  - Requires Significant Information and Institution Building at Local and Regional Levels
  - National/Macro Approaches Not Enough for 50%-80%?
- **At Scale, In Time, and For All**
  - Overemphasis on GHG Mitigation vs. Adaptation?
  - Overemphasis on Climate Change vs. other Sustainability Challenges? Affordability & Affluence?
  - Capturing Co-Benefits May Be Key to Rapid Deployment

***Thank You.***

**MIT*ei***  
MIT Energy Initiative



Source: NASA

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