

Wind Power in the US to 2030

***An Industry Perspective on the DOE/NREL/AWEA Wind Vision
and Roadmap Effort***

James A. Walker

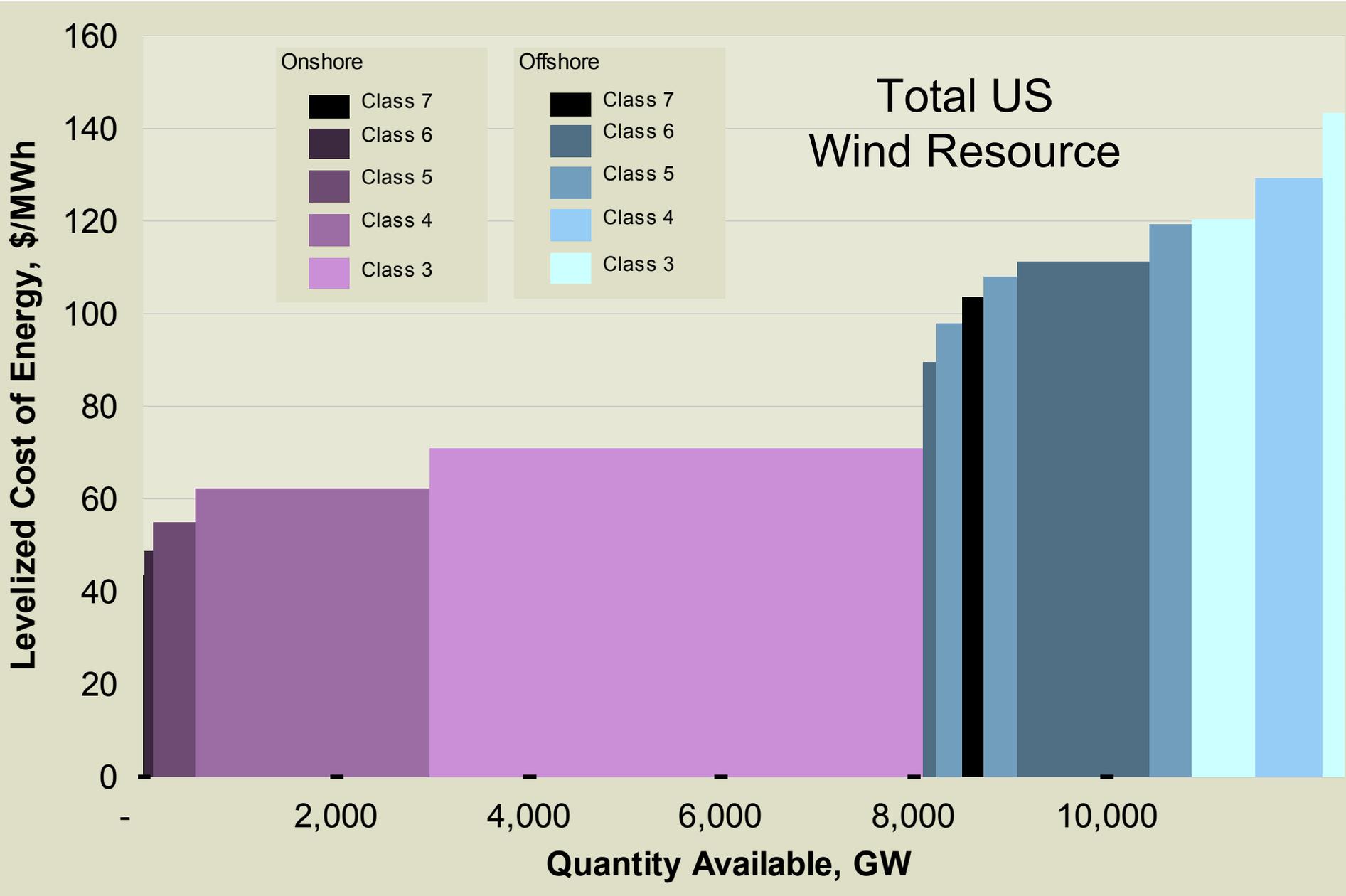


A Truly Remarkable Effort

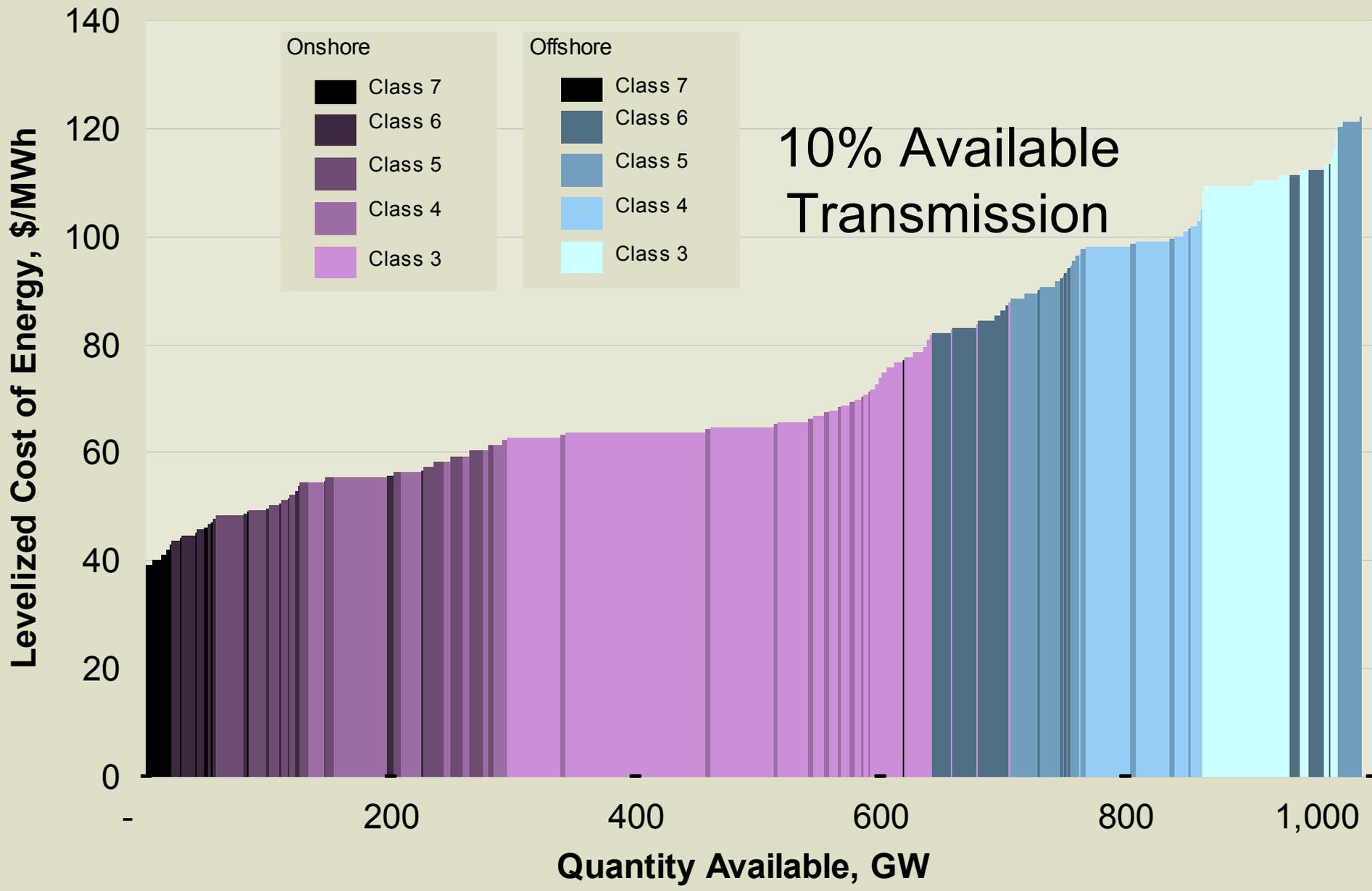
- Unprecedented cooperation between wind industry leaders and advisors, government, NGOs.
- First credible long term national view of wind energy's potential, costs, benefits, and challenges
- Should be viewed as a toolkit and set of capabilities, not just a report
 - Tools should continue to be developed and exercised
- Will be used by AWEA as basis for 5 year action plan.

How Big Can We Be If We Grow Up To Be All We Can Be?

- Affordable resource potential not the constraint
- Wind is part of a portfolio, not a stand alone supply source for a modern economy
- Black & Veatch Wind Vision Analysis – part of DOE/NREL/AWEA effort
 - Developed national and regional “supply curves” for wind – with unprecedented input from front line industry participants, DOE/NREL, & others



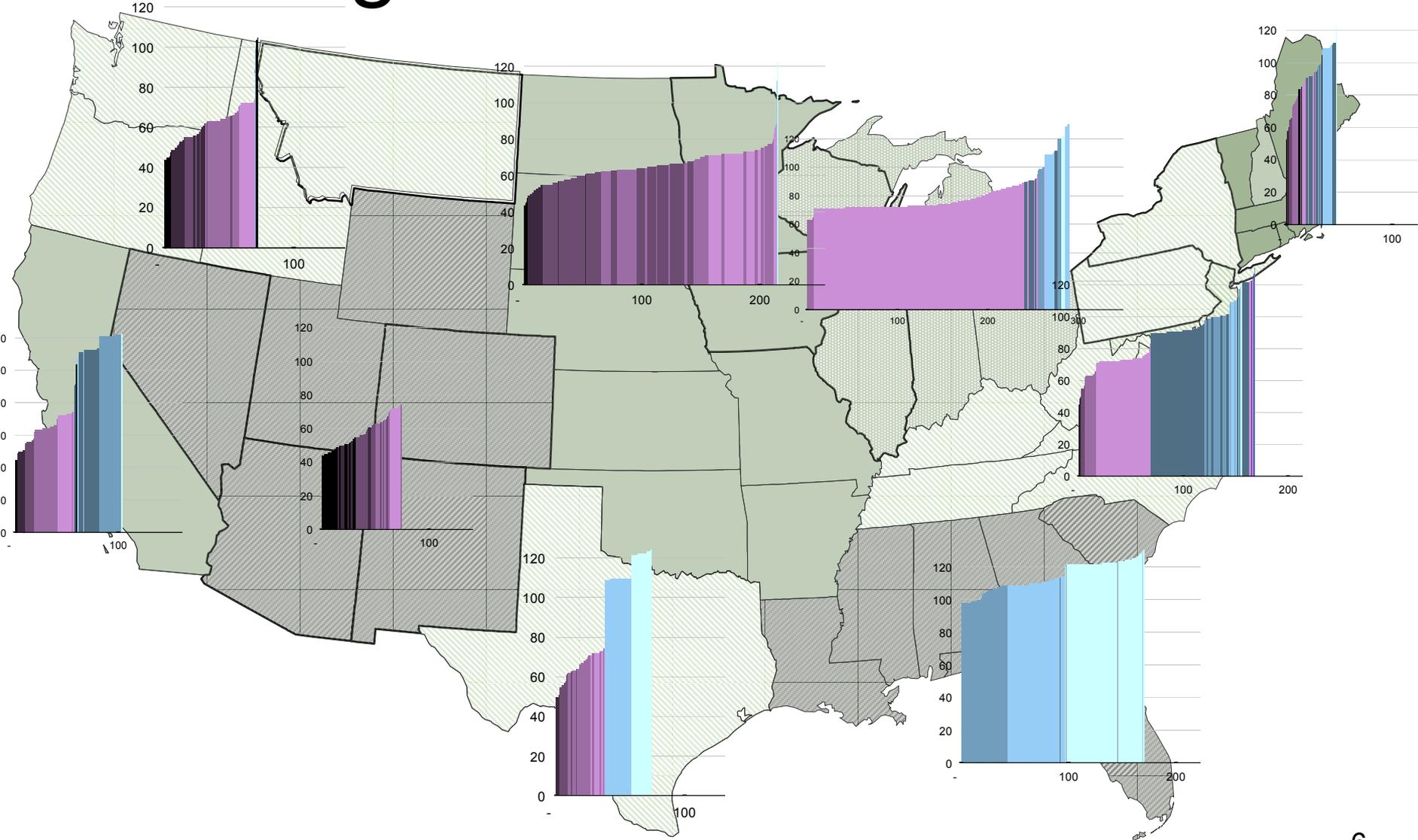
2010 Costs w/ PTC, w/o Transmission or Integration costs



10% Available
Transmission

2010 Costs w/ PTC, \$1,600/MW-mile, w/o Integration costs

Regional Wind Resource

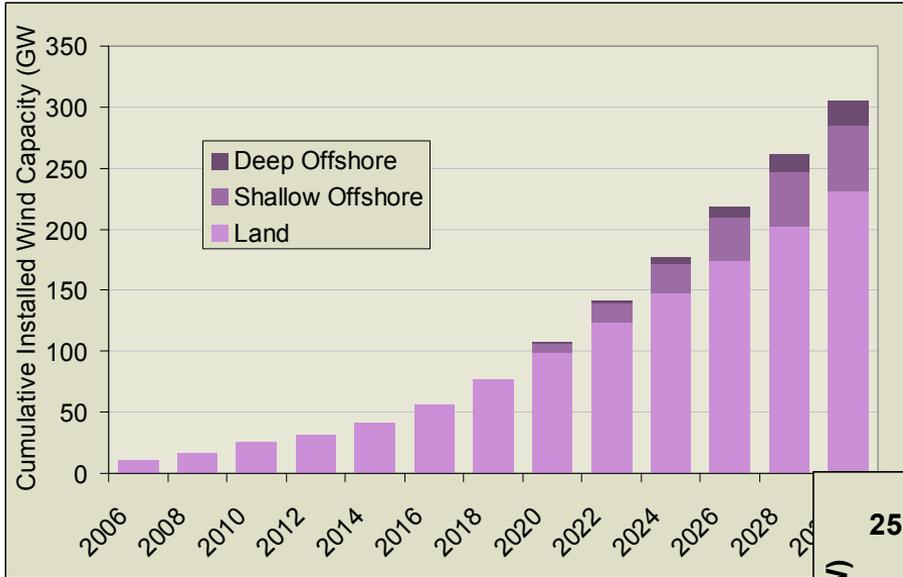


GW of wind by region

	Total	Onshore Only	\$65 or less
New England	41	16	4
Pacific NW	61	60	44
Texas	63	33	16
Mountain	63	63	51
California	88	49	33
Mid Atlantic	143	58	14
Southeast	145	1	0
Central Plains	184	182	96
Great Lakes	247	207	7
Total	1,031	669	264 ⁷

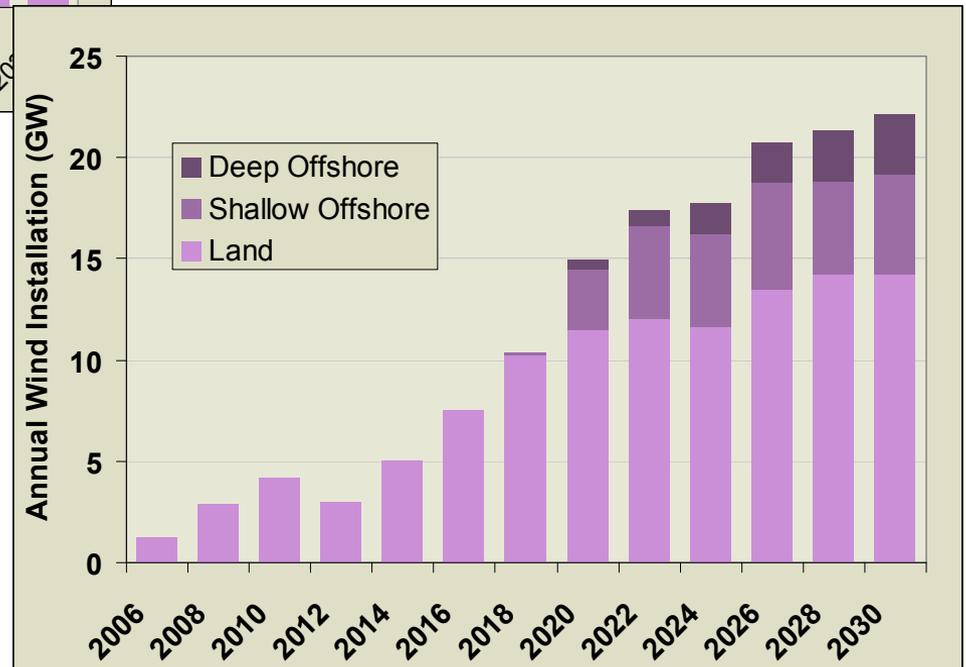


A High Growth Scenario



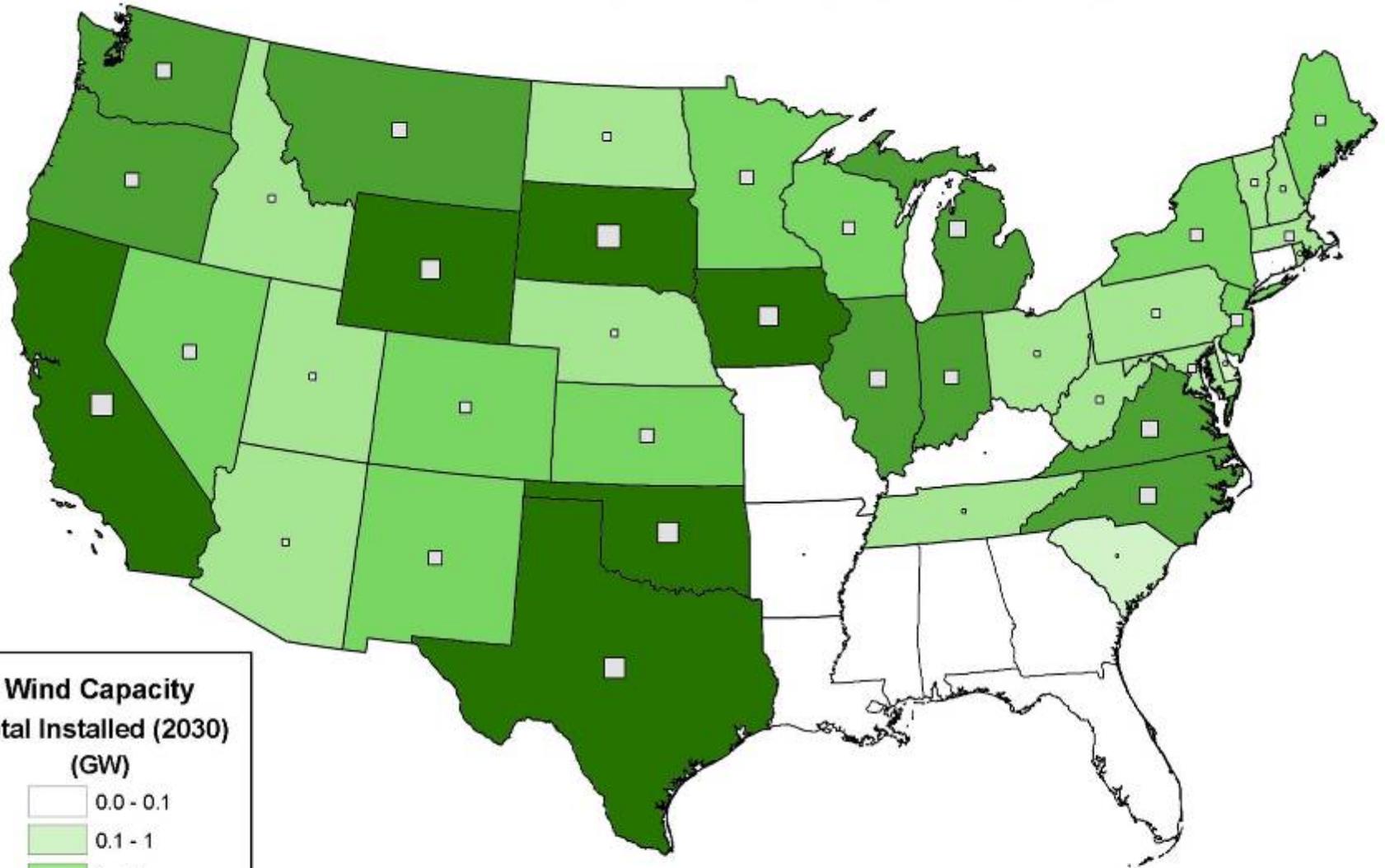
**WARNING: THIS IS A
SCENARIO- AN OPPORTUNITY
- NOT A PREDICTION – NOT
TO BE USED WITHOUT
CHILDREN’S GUIDANCE**

300 GW ~ 1/6 of a wedge

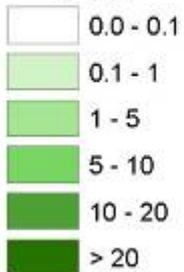


Illustrative Geographic Distribution

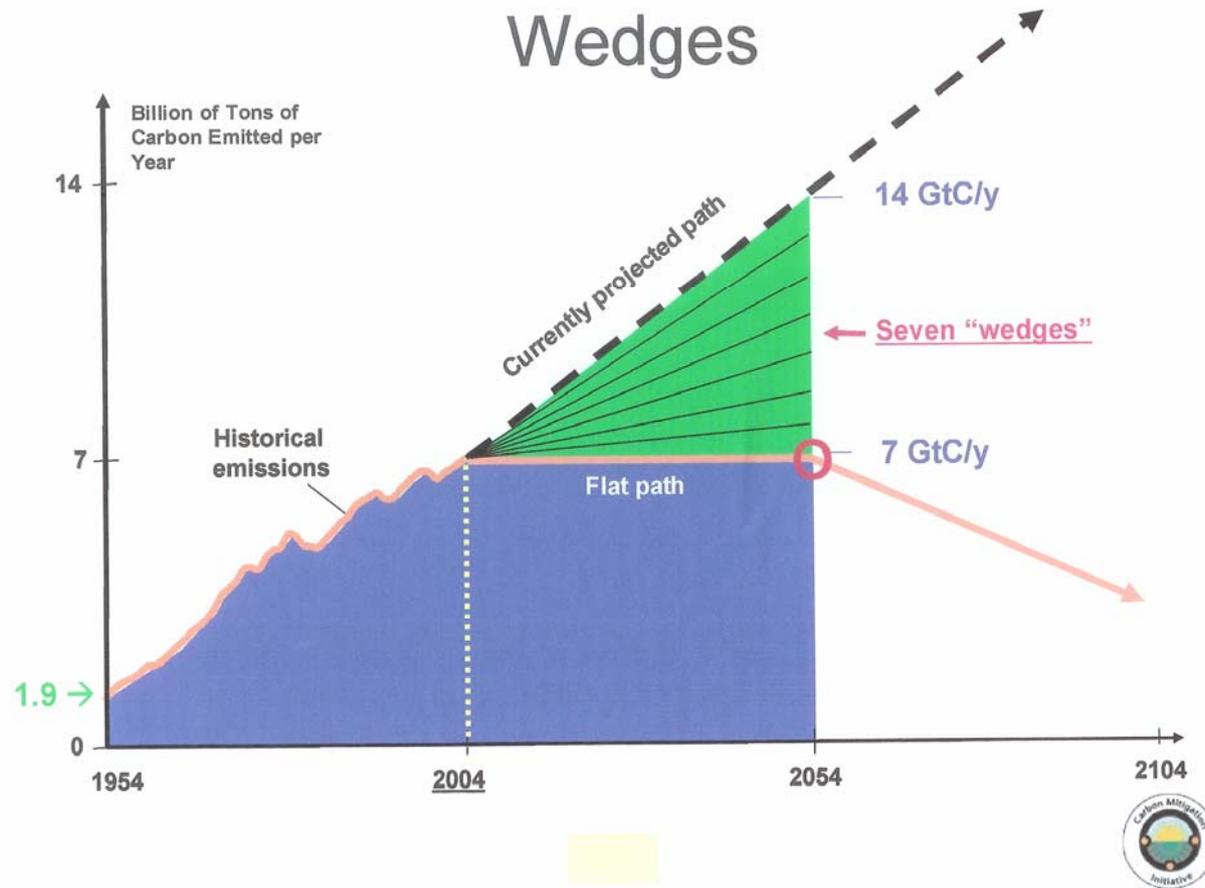
Installed Wind Nameplate Capacity by State (2030)



Wind Capacity
Total Installed (2030)
(GW)

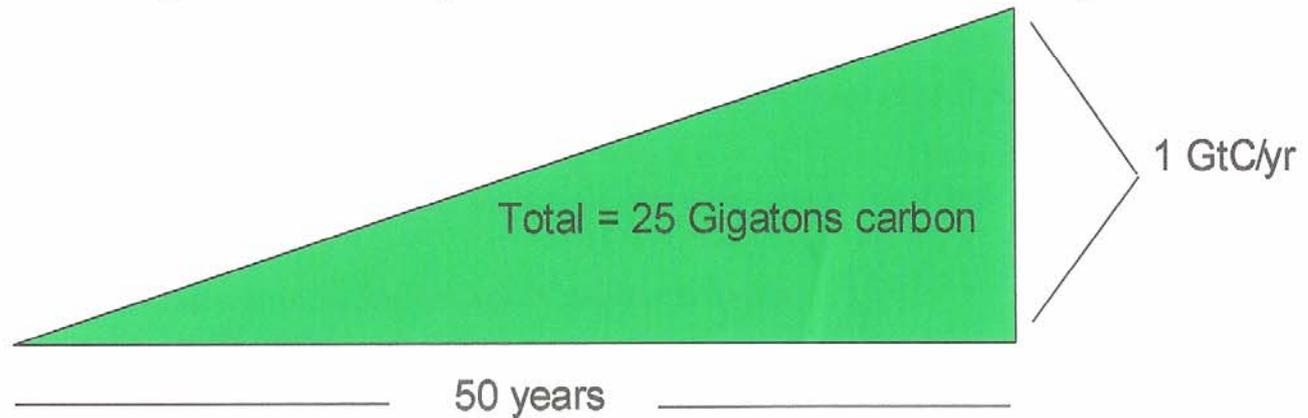


The Wedge Politics of Wind



What is a “Wedge”?

A “wedge” is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr.

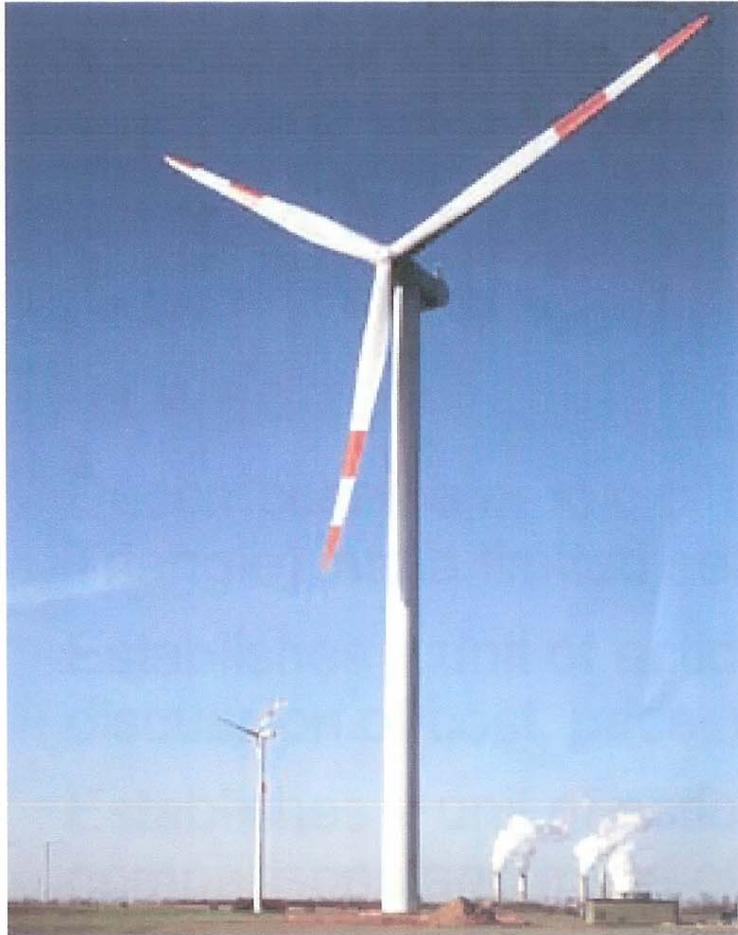


Cumulatively, a wedge redirects the flow of 25 Gt(C) in its first 50 years. This is 2.5 trillion dollars at \$100/t(C).

A “solution” to the Greenhouse problem should have the potential to provide at least one wedge.



Wind Electricity



**Effort needed by 2054 for
1 wedge:**

Two million 1 MW windmills
displacing coal power.

Today: 40,000 MW (2%)

*Prototype of 80 m tall Nordex 2,5 MW wind turbine located in Grevenbroich, Germany
(Danish Wind Industry Association)*



Siting and Policy Task Forces

- **Environment**

- Scale up to 10,15,20% requires new thinking beyond good project development practices
- “The future is now”
- Proactive approach by industry needed & worth the risks

- **Policy**

- Next 8 years – key for wind & global warming
- Strong rationale for long term national policies
 - But “policy subsets” – e.g. transmission & wildlife – equally necessary
- Wind is ready, willing and able to be a major component of the US energy portfolio

Policy Challenges Along the Way

- Can we create the needed long term investment climate?
 - Attracting \$500B+ for wind projects and transmission
 - Getting back on a declining cost path
- Can we remove the roadblocks in time?
 - Breaking the transmission Catch-22
 - Scaling up siting/permitting to 15-20 GW/year gracefully
- Will the customers be there for 100s of GW?
 - Industry fate may be determined in ~200 utility/PUC boardrooms
 - Each utility system has to prove to itself it can live with large variable resource penetrations
- Are we wise enough to share the pie?
 - Avoiding the PURPA zero sum game
 - Bringing the supply chain back from “over there”
 - Creating local opportunities along with local impacts
 - Funding for research, planning, mitigation and training
- Avoiding short attention span theater & parochialism
 - This is a 50-year play
 - Need to “hang together” with DSM and other renewables

Options for Sending the Right Investment Signals

Policy Option	Pros	Cons
Production Tax Credits (PTCs) (e.g., 1.9 cents/kWh for 10 yrs.)	Incentive tied to output, not nameplate; effectiveness known; provides project finance certainty with ability to control program	Direct, visible impact on budget deficit (+/-); available to very few investors; prone to boom-bust, adding 15%+ to costs; not directly linked to MW or % targets
Renewable Portfolio Standards (RPS) (e.g., TX 5,880 MW by 2015)	Can directly link to a % or MW goal; works at state or federal level; allows different RES to compete; costs spread over ratepayers benefiting	Details key to effectiveness (e.g., penalties for non-compliance); does not guarantee bankable PPA; objections to “quotas”;
Investment Tax Incentives (Investment Tax Credits, MACRs depreciation, etc.)	Lowers the cost of delivered wind energy; can be applied at state or federal level; are known at completion	Does not incentivize output; few investors qualify; not tied to MW or % target
Direct Grants for Production or Investment (e.g., MN MIPS, CA SEPs, REPIs or Greek 30% investment grants)	Can be used by wide range of investors; can be auctioned off for efficiency; can be scaled down over time.	Cost to govt. budgets limits availability and stability; can lead to “gaming” of investment cost;
Feed-in Tariffs (e.g., CA Standard Offers, German law)	Proven to attract investment; can be paid by ratepayer or taxpayer;	Ratepayer objections; may not adjust to change in market (e.g., turbine price increases)
Markets for RECs (e.g., New England, UK, Italy)	Uses market mechanisms to level the field; reduces dependence on govt policy; potential for efficient price signals	Hard to establish well-functioning markets; volatility in pricing;
Carbon Tax	Can be set to match estimated external costs; gives efficient price signal to all forms	Objections to new taxes; not targeted exclusively to wind/RES (e.g., helps nuclear, too);

Success in One Policy Arena Is Not Enough

Policy Group 1 - Life Cycle Supply Chain

- Building a manufacturing base
- Financial engineering & risk management
- Optimizing operations safely
- Repowering & recycling
- Growing the export opportunities

Policy Group 2 - Siting & Stewardship

- Scaling up planning & permitting processes
- Mapping the future (literally)
- Enabling onshore, offshore, community and small wind
- Enhancing national security

Policy Group 3 - Working Within the System

- Transmission expansion
- Utility System Integration
- Making the case in utility and PUC boardrooms
- Making more markets work

Policy Group 4 - The Human Side

- Training the best and brightest
- Biologists when and where we need them
- Public servants empowered to give good service

Policy Group 5 - Expanding the Knowledge Base

- Sustaining world class R&D
- Wind/wildlife interactions
- Technology for mitigation
- Policy analysis for RES
- System integration enhancements

Policy Group 6 - Distributing the Benefits

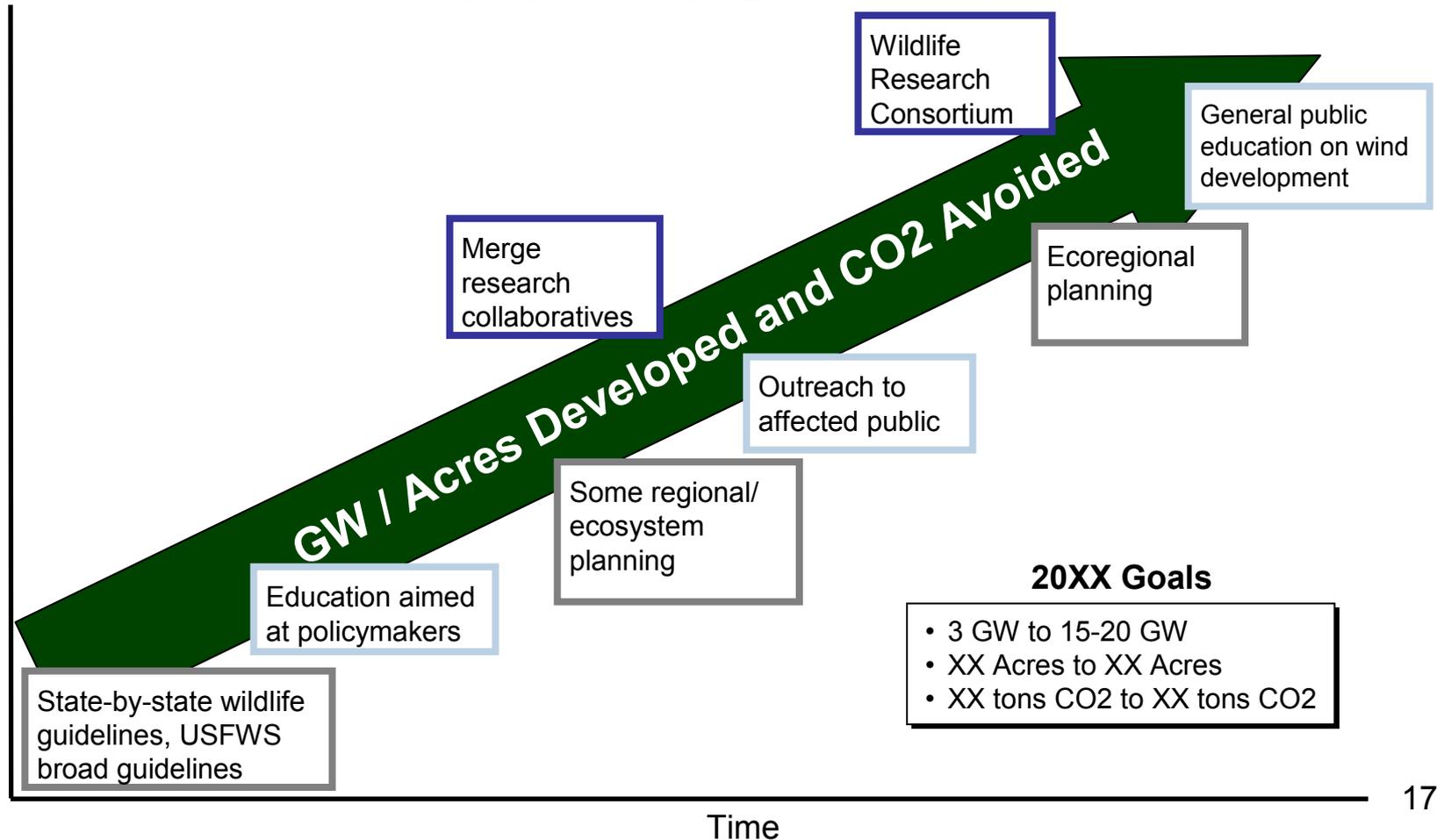
- "What gets rewarded gets done" - for each link in the supply chain
- Expanding investment opportunities
- Native American and rural development driver
- Giving back to Mother Nature through mitigation funds

Policy Group 7 - Getting the Word Out

- Public awareness
- Informing key decision makers
- Science-based the norm
- Open procedures
- NGO/GO/PMO outreach
- Responding to misinformation

Environmental Issues – Procedures and Knowledge Base Must Grow With the Industry

The Path to 15-20 GW / Year



Two Signs of the Times



No Fuss*, No Mess - No Burning or Boiling Required - *Just Add Wind*

Estimated Water Savings from Wind Energy in the Interior West, 2003

Wind Energy	Water Savings (gallons withdrawn)	Water Savings (gallons consumed)
1200 MW	3.15 billion	1.89 billion
3000 MW	7.88 billion	4.73 billion
4000 MW	10.51 billion	6.31 billion

Source: Adapted from "The Wind/Water Nexus" Wind Powering America

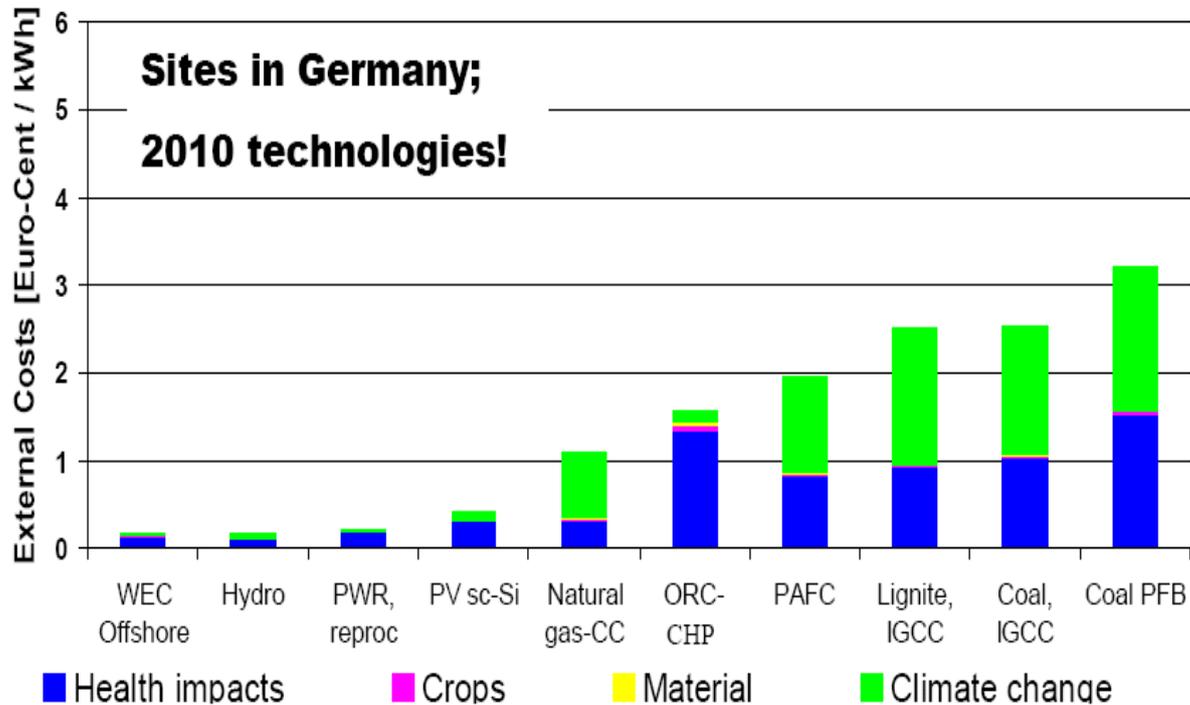
* Some fuss may be involved in sensitive areas

Major Market Distortion: External Costs of Fossil Fuels not Reflected in Pricing

(The PTCs are a bargain)

External Costs of Power Stations [Euro-Cent / kWh]

19 Euro/t CO₂, Nitrates = 0.5 PM₁₀, YOLL_{chronic} = 50.000 Euro



Source: ExterneE project, European Commission

EXTERNAL COST FIGURES FOR ELECTRICITY PRODUCTION IN THE EU FOR EXISTING TECHNOLOGIES¹
(IN € CENT PER KWh*)

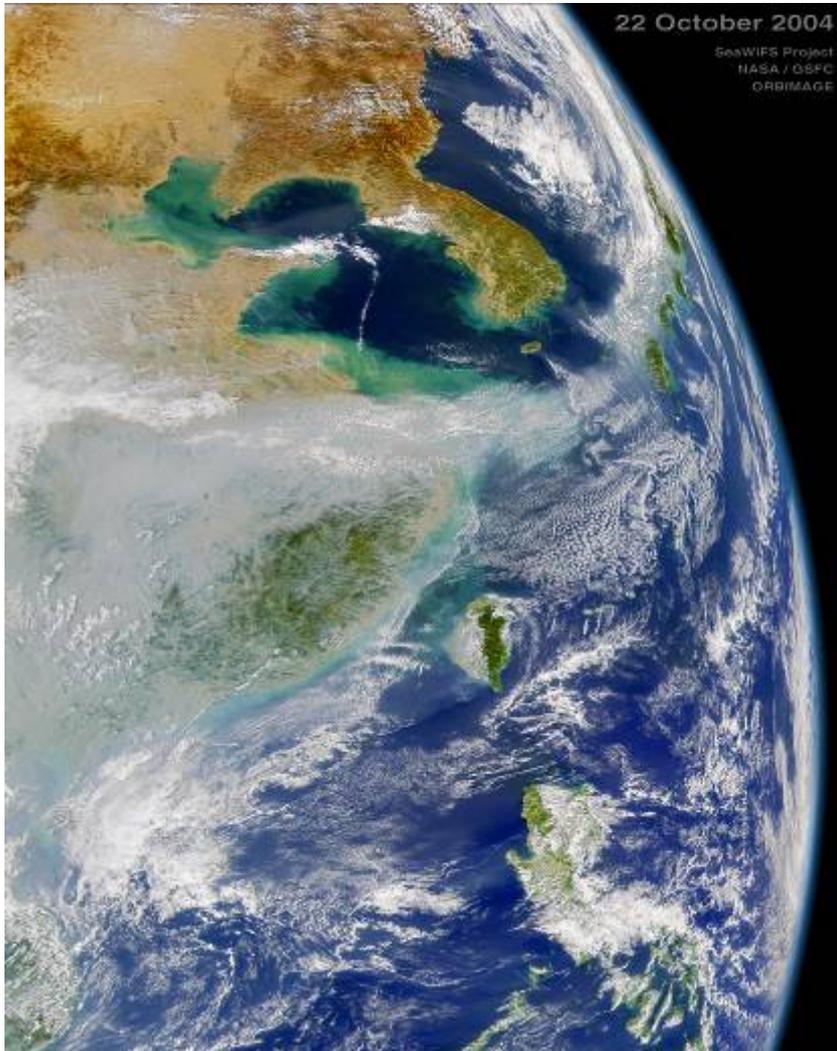
Country	Coal & lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
AT				1-3		2-3	0.1		
BE	4-15			1-2	0.5				
DE	3-6		5-8	1-2	0.2	3		0.6	0.05
DK	4-7			2-3		1			0.1
ES	5-8			1-2		3-5**			0.2
FI	2-4	2-5				1			
FR	7-10		8-11	2-4	0.3	1	1		
GR	5-8		3-5	1		0-0.8	1		0.25
IE	6-8	3-4							
IT			3-6	2-3			0.3		
NL	3-4			1-2	0.7	0.5			
NO				1-2		0.2	0.2		0-0.25
PT	4-7			1-2		1-2	0.03		
SE	2-4					0.3	0-0.7		
UK	4-7		3-5	1-2	0.25	1			0.15

* sub-total of quantifiable externalities (such as global warming, public health, occupational health, material damage)

** biomass co-fired with lignites

Source: ExternE program, European Commission

Global Smog is here already



“The U.S. Environmental Protection Agency estimates that on certain days nearly 25 percent of the particulate matter in the skies above Los Angeles can be traced to China. Some experts predict China could one day account for a third of all California's air pollution.”
(ABC News)

2006 National Audubon Society

John Flicker, National Audubon Society, president *

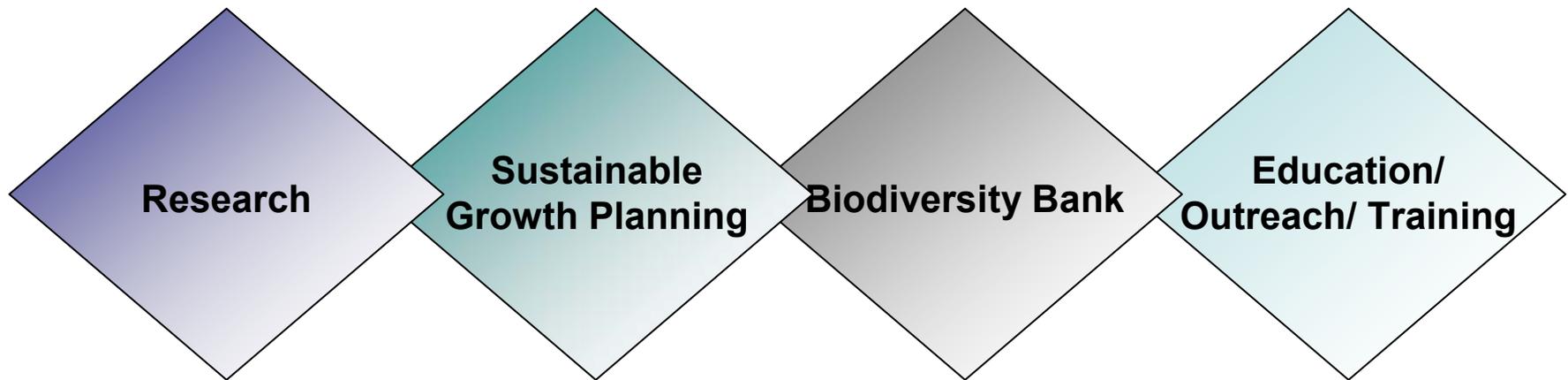
"[Audubon] strongly supports wind power as a clean alternative energy source," pointing to the link between global warming and the birds and other wildlife that scientist say it will kill.

"It [Global Warming] creates a sense of urgency beyond anything we have seen before...I want to make sure Audubon is doing everything we can to promote both conservation and wind energy."

"When you look at a wind turbine, you can find the bird carcasses and count them...with a coal-fired power plant, you can't count the carcasses, but it's going to kill a lot more birds."

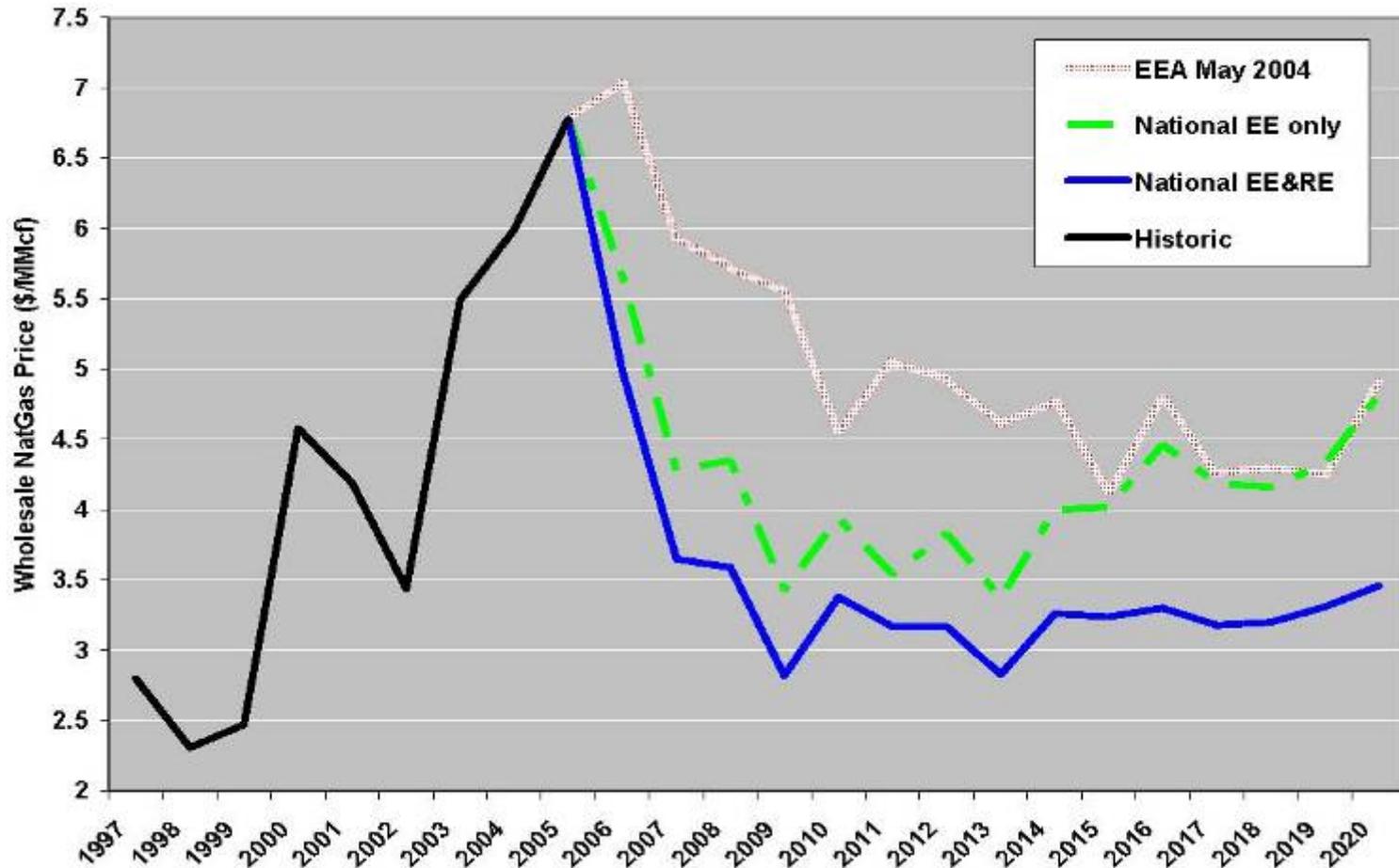
American Wind Wildlife Institute

An AWEA Initiative in Process



Green Energy is a Terrible Thing to Waste

(So don't waste it! Save \$\$\$ on natural gas and make meeting 20% easier at the same time)



Source: ACEEE-ACORE

A Trillion Dollar Opportunity

Investment	Units	2005	2010	2015	2020	2025	2030
Inflation Index @ 2.5% (mid period)		100%	106%	113%	120%	128%	136%
GW added per 5 yr period	GW	8	50	60	65	75	80
GW on line end of period	GW	10	60	120	185	260	340
Installed cost/kW	\$/kW	\$1,600	\$1,702	\$1,810	\$1,926	\$2,048	\$2,179
Investment per 5 year period	\$B		\$85	\$109	\$125	\$154	\$174
Cumulative investment	\$B		\$85	\$194	\$319	\$472	\$647
All \$ nominal, current year \$.							
Annual revenues							
Tariff (incl PTCs or equivalent externality credit)	\$/MWH	\$70	\$74	\$79	\$84	\$90	\$95
Power Sales	\$B	\$2	\$12	\$25	\$41	\$61	\$85
Development Revenue	\$B		\$17	\$22	\$25	\$31	\$35
Wind industry revenues in yr noted	\$B		\$29	\$47	\$66	\$92	\$120
Cumulative Total Revenues	\$B		\$119	\$286	\$484	\$728	\$1,043

Personal Conclusions

- The optimal share of wind in the US power generation portfolio is between 15 and 30% - probably towards the high end
- The more comprehensive the evaluation criteria, the better wind looks
- We have the resources, technology, development and financing capability to achieve this in the 2020's
- The financial, job, consumer and environmental benefits far outweigh the direct costs
- The current levels of "subsidies" for wind are well-justified
 - PTCs do not even fully capture the benefits of a "no burn/no water use" technology.
 - High wind penetration = natural gas displacement = gas/electric consumer savings
- The international competition is tough and getting tougher
- The greatest policy challenges are
 - Cutting through the transmission mess
 - Providing long term policy stability through any one of several proven means (PTCs, RPS, tradeable RECs)
 - Winning the hearts, minds and boards of US utilities
 - Providing local benefits for local impacts
 - Rebuilding the US manufacturing base
 - Dramatically scaling up the scope and level of public and private funding for R&D and deployment preparation.
- Doing all of the above for energy efficiency and transportation at the same time
- *All in all, this is opportunity of a lifetime: It is rare indeed to have a policy option with so much upside, so little downside, and so much certainty of significance and success*



Cover Slide Painting by Esref Armagan

“If he can have a vision and roadmap for
wind, shouldn't we?”



Esref Armagan was born unsighted to an impoverished family. As a child and young adult he never received any formal schooling or training; however, he has taught himself to write and print. He draws and paints by using his hands and primarily oil paints. In this manner, Mr. Armagan has been perfecting his art for the past thirty-five years.

He needs absolute quiet when working. First, using a Braille stylus, he etches an outline of his drawing. He needs to feel that he is "inside" his painting-- in fact, when he is drawing a picture of the sea, he often wonders if he should wear a life jacket so as not to drown! When he is satisfied with his drawing, he starts to apply the oils with his fingers. Because he applies only one color at a time (the colors would smear otherwise), he must wait two or three days for the color to dry before applying the next color. This method of painting is entirely unique to Mr. Armagan. He receives no assistance or training from any individual. He also learned to draw perspective.

He has also developed his own methods of doing portraits. He asks a sighted person to draw around a photograph, then he turns the paper over and feeling it with his left hand, he transfers what he feels onto another sheet of paper, later adding color. He has done portraits of the former first lady of Turkey, the current president and current prime minister.

Mr. Armagan is currently forty-one years old, married with two children. He has displayed his work at more than 20 exhibitions in Turkey and in Holland and the Czech Republic. He has appeared several times on television and in the press in Turkey and has been on programs of the BBC and ZDF.

See: www.esrefarmagan.com or www.armagan.com