CLEAN TECH 101

FEBRUARY 4, 2009 WEBINAR

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Thank You

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For the use of a conference room at the Foley Hoag

Emerging Enterprise Center

Waltham, MA

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Agenda

- Transitioning into Clean Tech
- Global Energy Trends and Issues
- Clean Technology Sector
- Financing Trends
- Policy Framework
- Information Sources
- Conclusion

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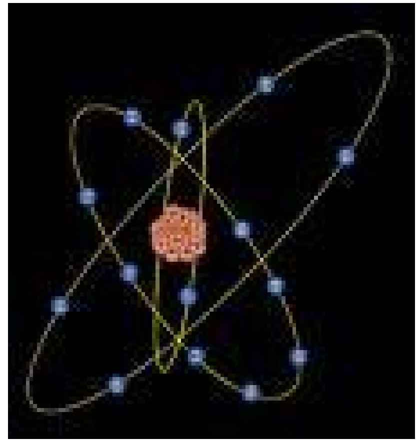
My Story

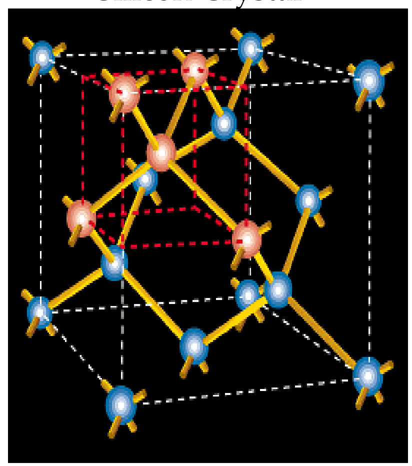
Semiconductors ⇔ Solar Cells

- •CFO to clean energy early stage companies
- •Long standing interest in the field
- •Began career as business unit controller at TI
- •Recruited to Analog Devices by former colleague
- •Financial and Operational Roles over 20 years at ADI
- •Transition from ADI in 1997
- •Reasoned that semiconductors to solar cells s/b easy
- •Colleague with PhD in solar cell physics
- •Independent consulting in the meantime
- •Went to work for SELCO in 1999
- •Left in 2002 due to slow exit
- •CFO for consulting and training firm until 2007
- •Clean Tech hot in Boston
- •Focusing my efforts in Clean Tech for past 1.5 years

Silicon Atom



Silicon Crystal



Source: About.com

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Takeaways

- Current energy trends are unsustainable
- Solar and Wind have been growing fast
- Solar is still costly but Wind is not
- Venture Capital is flowing to the sector
- Project financing is crucial
- Think broadly about the sector
- Look closely at Efficiency

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Global Energy Trends and Issues

- Energy security and economics
    - 70% of Oil Reserves reside in OPEC countries
    - 65% of US consumption is imported oil
    - At 5 billion barrels and $50/bbl - oil imports cost $250 billion
    - Current Account deficit stands at more than $700B
    - Clean Tech means more jobs in the US and less foreign entanglement
- Energy and the environment
    - Historical CO_2 levels varied between 175 ppmv and 300 ppmv
    - Temperature is highly correlated with CO_2
    - Current CO_2 is 380 ppmv
    - Current CO_2 emissions exceed 30 billion metric tons
    - 1990-80% reduction target means 4.3 billion metric tons
- Sustainability
    - WW electricity usage is more than 18,000 TWh
    - Official IEA projections say 33,000 TWh by 2030
    - WW total energy consumption is more than 450 Quadrillion BTUs
    - Official IEA projections say 650 Quads by 2030
    - Peaking Oil?
- US share of global energy
    - 100+ Quads out of 450+ Quads are used in USA
    - Only 2 Quads of oil support production of electricity
    - Less than 7 Quads at the source are "renewable"
    - Renewable Portfolio Standards (RPS) require 20% by 2020 or 25% by 2025
    - Only a little more than 2 Quads out of the "renewable" total will qualify

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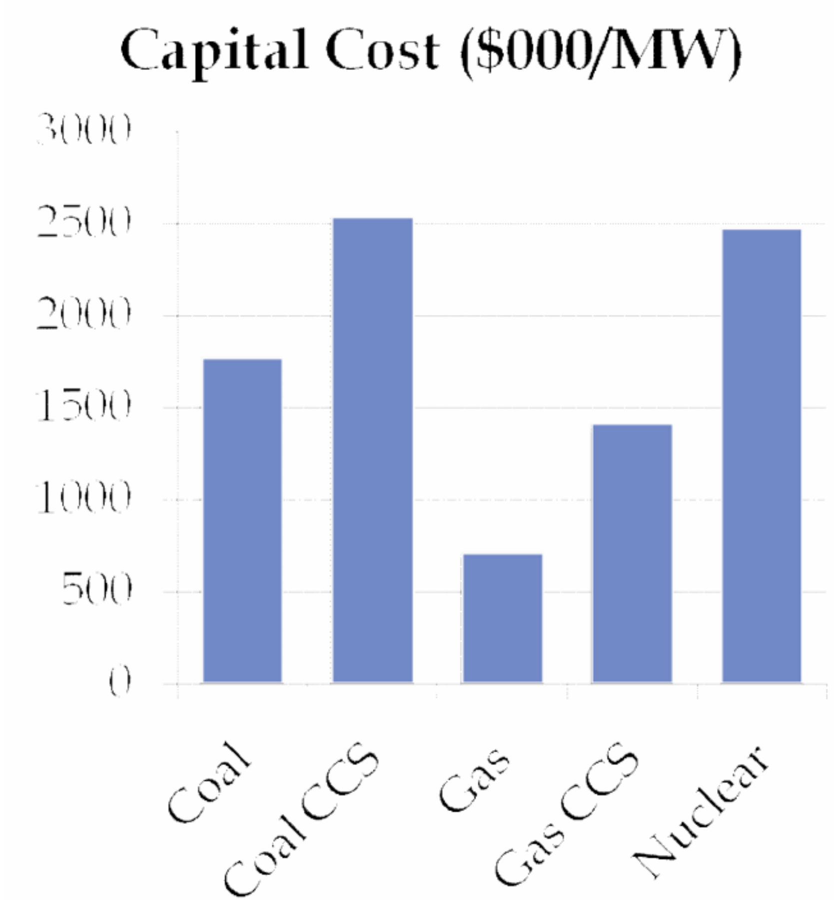
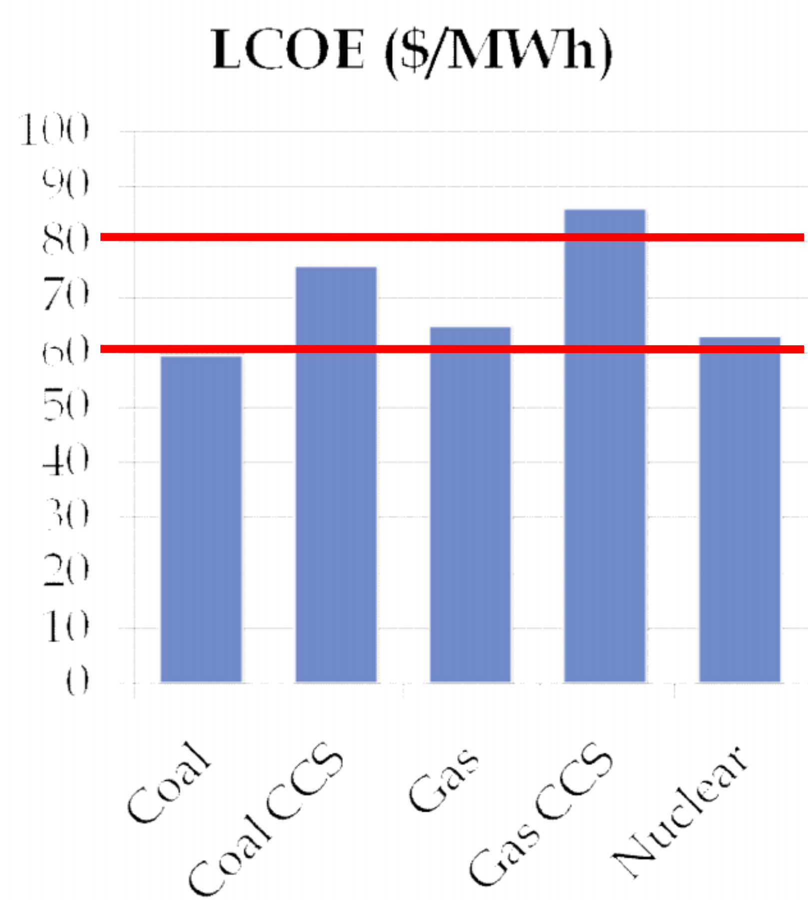
Projected Electricity Costs → 2030





Source: Energy Information Administration – Annual Energy Outlook 2008
Report#: DOE/EIA – 554(2008)

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Definition

- Clean Technology
  - Innovations that create diversity and efficiency[1] in the production and use of energy while reducing harmful environmental impact **(and promoting sustainability)**

[1] To learn more from the guru of efficiency go to Rocky Mountain Institute

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What comprises the Clean Tech Sector?

- Google “Greentech Media Market Taxonomy”
- Sector companies serve all economic tiers
  - Personal
  - Residential
  - Commercial
  - Industrial
  - Government
  - Utility
- Innovations target for example
  - Services such as power providers and demand response
  - Transportation e.g. bio-fuels, batteries, fuel cells, electric vehicles
  - Efficiency e.g. LEDs, Energy IT, Intelligent Network Devices and Sensors, Smart Grid, High Voltage DC Transmission, Fuel Consumption
  - Power generation e.g. solar, wind, geothermal, hydrokinetic, bio-mass, nuclear, clean coal
  - Energy storage e.g. compressed air, flywheel, flow batteries, solid oxide fuel cells
  - Materials such as cement, drywall and other building materials

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Energy Efficiency ⇔ EnerNOC

Note: Ticker Symbol: ENOC; Last 9.68 52-Wk High 37.47 52-Wk Low 4.80

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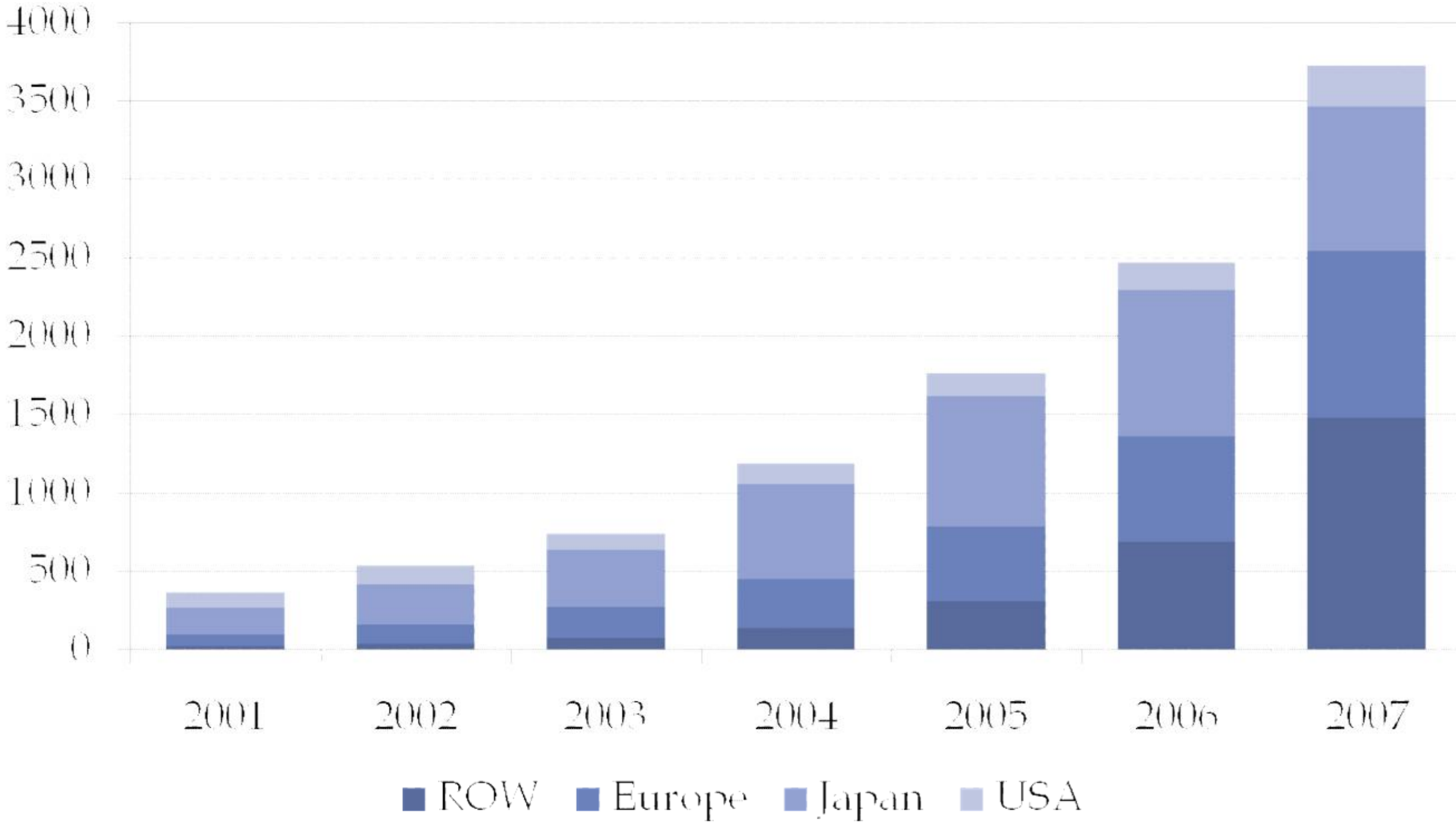
Global Solar Cell Production (MW-dc)



Source: *PVNews™ March 2008*

greentechmedia: Prometheus Institute

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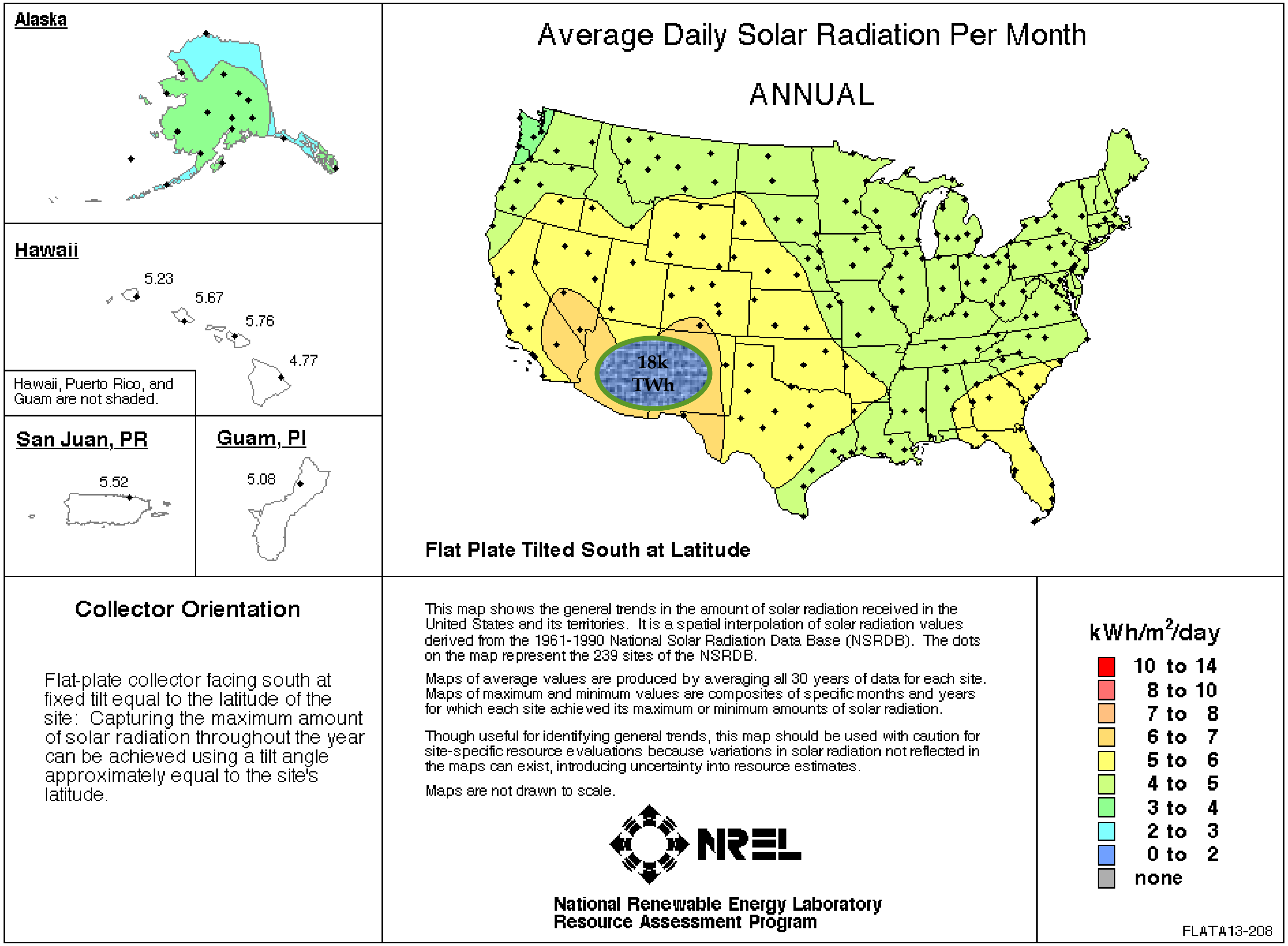
Solar Radiation (kWh per square meter per day)



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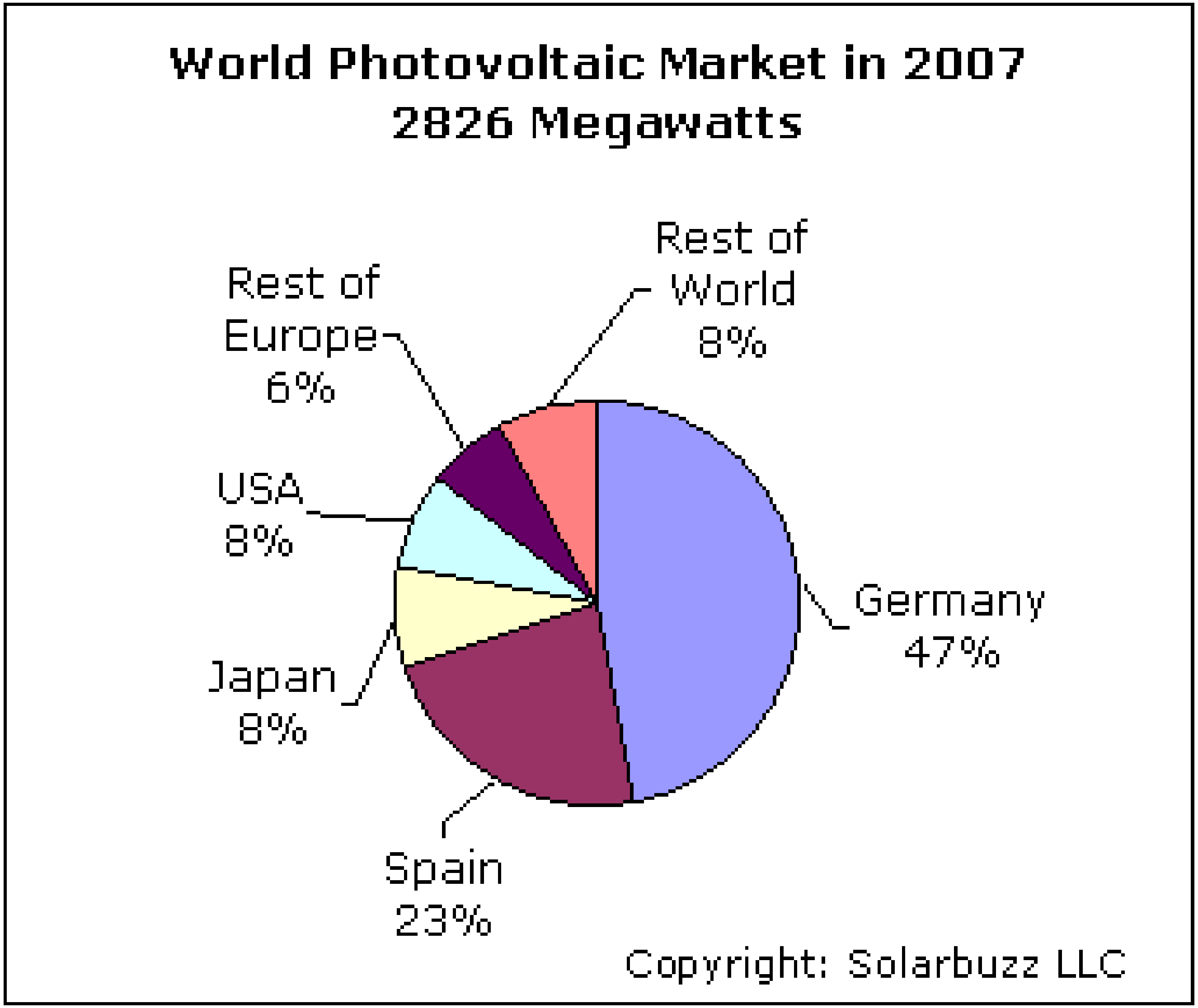
Solar PV Installed Capacity



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Cost of Electricity → Central Solar PV Power Station

Cost Factors	2007	2009	2011	2013	2015
$ per kWp	$4,800	$4,080	$3,468	$2,948	$2,506
O&M $ per kW-year	$12.00	$10.07	$8.46	$7.10	$5.96
Capacity Factor	21%	21%	21%	21%	21%
Project Life in years	20	20	20	20	20
Discount Rate	8%	8%	8%	8%	8%
Total Cost ($/kWh)	$0.26	$0.22	$0.19	$0.16	$0.14

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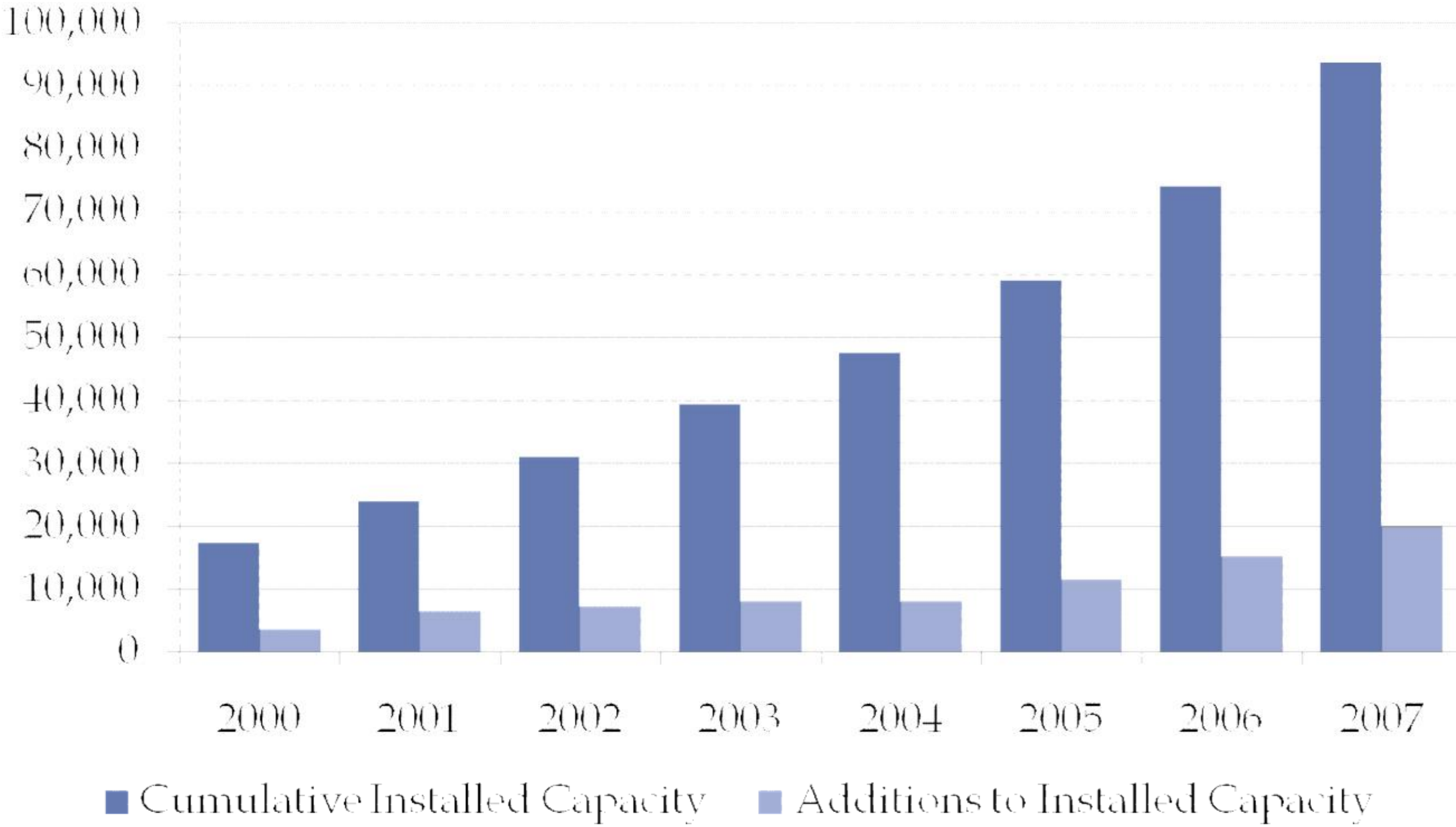
Global Trends with Wind (MW of Capacity)



Source: Global Wind Energy Council – Global Wind 2007 Report

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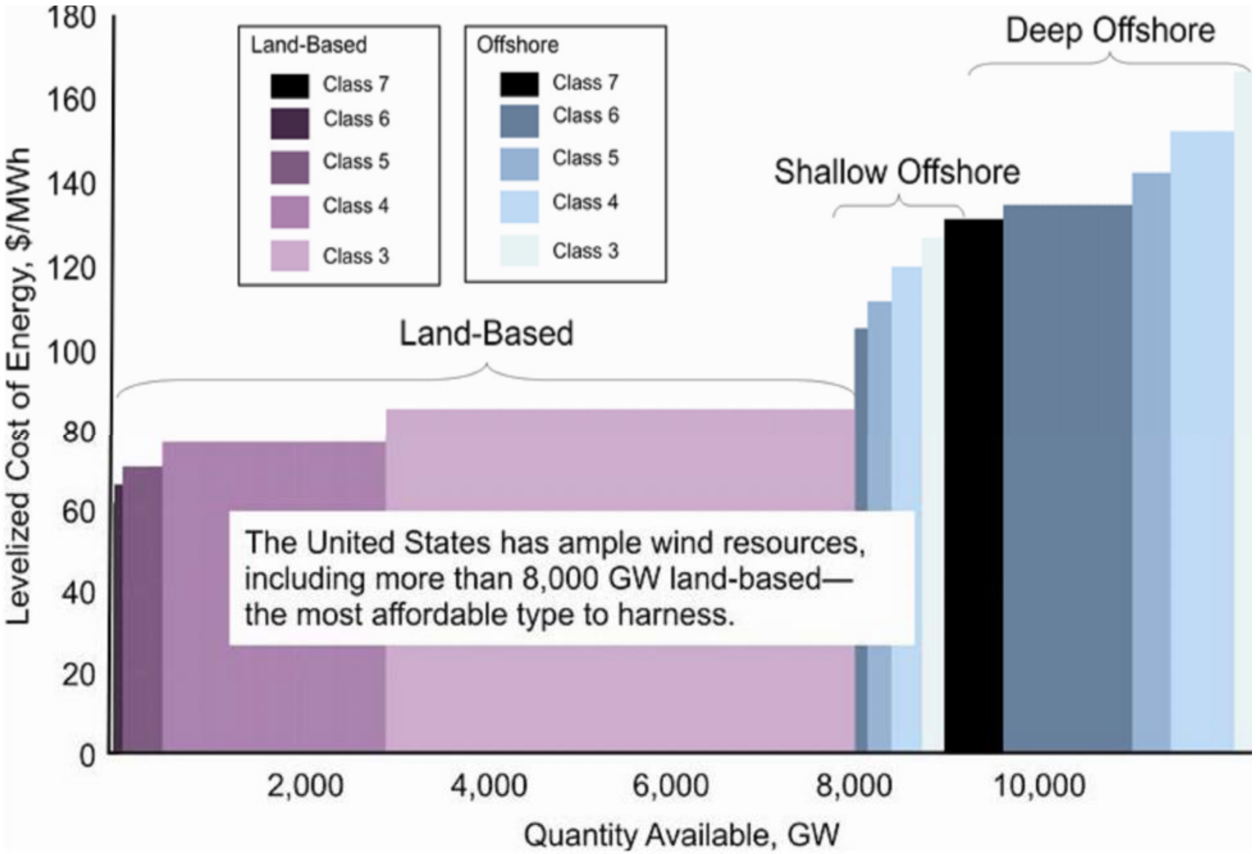
Wind Costs

Cost Factors	Amount
$ per kWp	$1,500
O&M $ per kW-year	$40.00
Capacity Factor	30%
Project Life in years	20
Discount Rate	8%
Total Cost ($/kWh)	$0.0725

Supply curve for wind energy—current bus-bar energy costs



Source: 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply - DOE/GO-102008-2567 • July 2008

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Biofuels

Type of Biofuel	Use	Source
Ethanol	Spark-ignited engines and specially equipped compression ignition engines	Fermentation of sugars
Biodiesel	Compression ignition engines or turbines	Plant oils usually transformed into fatty acid methyl esters (FAME)
Green diesel	Compression ignition engines or turbines	Plant oils transformed by ordinary refinery operations
Fischer-Tropsch diesel	Compression ignition engines or turbines	Pyrolysis of biomass followed by gas-to-liquids processing
Syncrude	Feedstock for a refinery	Pyrolysis of biomass

Source: Robert Weber, PhD, CTO - Sunrise Ridge Algae Inc.

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Projected Prices (Cents per Liter)

Biofuel	2006	2030
Ethanol from sugarcane	25-50	25-35
Ethanol from maize	60-80	35-55
Ethanol from beet	60-80	40-60
Ethanol from wheat	70-95	45-65
Ethanol from lignocellulose	80-110	25-65
Biodiesel from vegetable oils	70-100	40-75
Fuels from "syngas"	90-110	70-85

Note: For a range of $50 to $80 per barrel of oil gasoline is 35 to 60 cents per liter

Source: The Royal Society as reported in The Economist, June 21 2008, The Power and the Glory – A Special Report on Energy

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Financing ⇔ Venture Capital

Sector	Q3 Amt	# Deals
Solar	$1,586	26
EE, DR & Smart Grid	$272	14
Geothermal	$216	4
Automotive, Transportation	$193	8
Water Technology	$182	10
Ethanol and Bio-fuels	$150	8
Wind Energy	$141	8
Batteries and Fuel Cells	$49	4
Carbon and Energy Storage	$30	3
Green Building	$29	3
Green IT and Lighting	$27	4
Others	$11	3
Total	$2,886	88

Sector	Q4 Amt	# Deals
Solar	$1,336	29
Bio-fuels & Gasification	$359	18
Wind	$218	5
EE, DR, & Smart Grid	$208	11
Batteries, Fuel Cells, Storage	$102	14
Energy Project Development	$96	2
E-Waste and Recycling	$75	7
Green IT	$37	7
Automotive, Transportation	$29	4
Green Agriculture	$25	2
Lighting	$24	7
Others	$30	9
Total	$2,540	115

Source: Greentech Media

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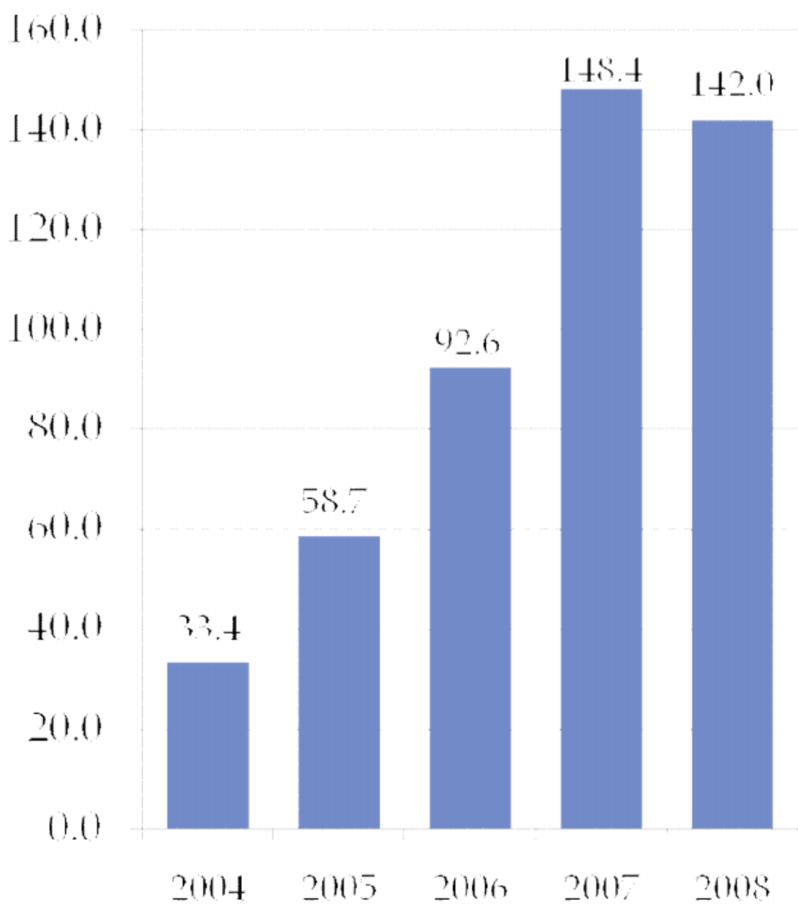
Overall Clean Energy Financing ($ billions)



Source: New Energy Finance

- 67% growth p.a. 2003-2007
- Of the $148.4 billion
  - $9.8 billion VC&PE
  - $84.5 billion project financing – equity & debt
- 2008 is down 4%
- World Economic Forum and New Energy Finance Report that $515 billion per year will be required to get to 450 ppmv CO_2 by 2030
- Go to http://www.weforum.org/pdf/climate/Green.pdf

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A Quick Overview with Some Specifics

- German Feed-in Tariff for solar pv
  - Ranges from $594 to $746 per MWh
- Federal Tax Credits
  - Solar Investment Tax Credit is 30%
  - Wind Production Tax Credit is $21 per MWh
- Many states have gotten into the act
  - Renewable Portfolio Standards
  - Solar Carve Out Standards
  - CO_2 Offset Programs
  - Renewable Energy Credits or RECs for Wind $20 per MWh
  - Solar RECS or SRECs in New Jersey $400 per MWh
  - Many financial incentives in a number of forms
  - Access laws for solar and wind
  - Interconnection standards and net metering
- Go to **http://www.dsireusa.org/** or **http://www.whitehouse.gov/agenda/energy_and_environment/** for more information

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Information Sources and Other Thoughts

- Free Weekly Newsletters – information about the sector and related events
  - http://apps1.eere.energy.gov/news/enn.cfm
  - http://www.greentechmedia.com/
  - http://www.renewableenergyworld.com/rea/home
  - http://www.greenbiz.com/
  - http://www.xconomy.com/
  - http://www.cleanedge.com/
  - http://www.smartelectricnews.com/
- Other Sources
  - http://www.eia.doe.gov/
  - http://www.virtualenergyforum.com/
  - http://www.rmi.org/
- Networking – "90% of life is just showing up" Woody Allen
  - Renewable Energy Business Network – rebn.org – look for local chapter
  - Business Calendar of Events
  - Energy Clubs and University Calendar of Events
  - Business Plan Competitions

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THANK YOU!

Questions?

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To download video and/or slides go to:
www.fiscaldoctor.com
Click on White Papers

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Bonus Slides Follow

- Extra credit will be given to any student who peruses these bonus slides on their own time.

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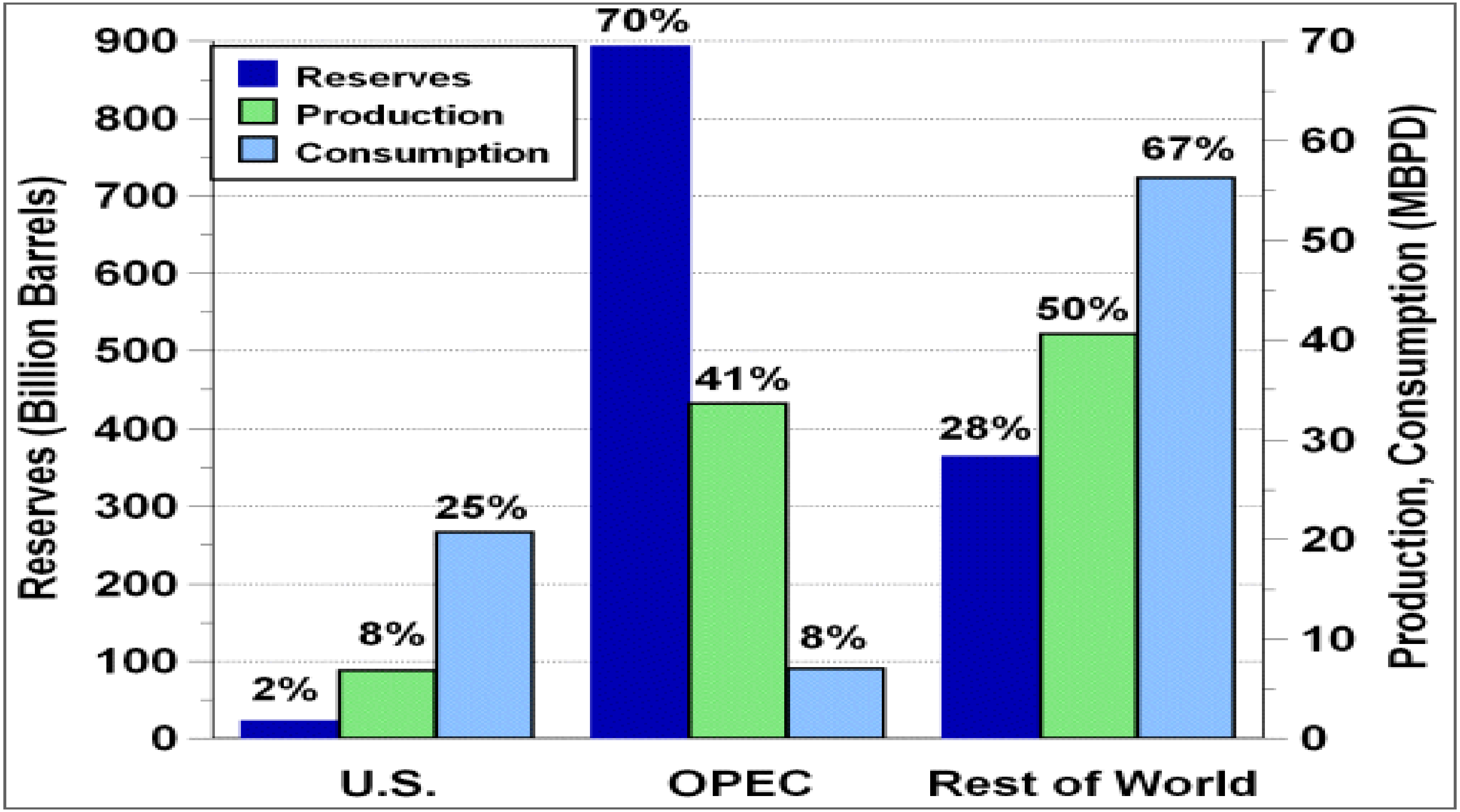
Energy Security (2005)



Source: http://www.eere.energy.gov/vehiclesandfuels/facts/2006_fcvt_fotw432.html

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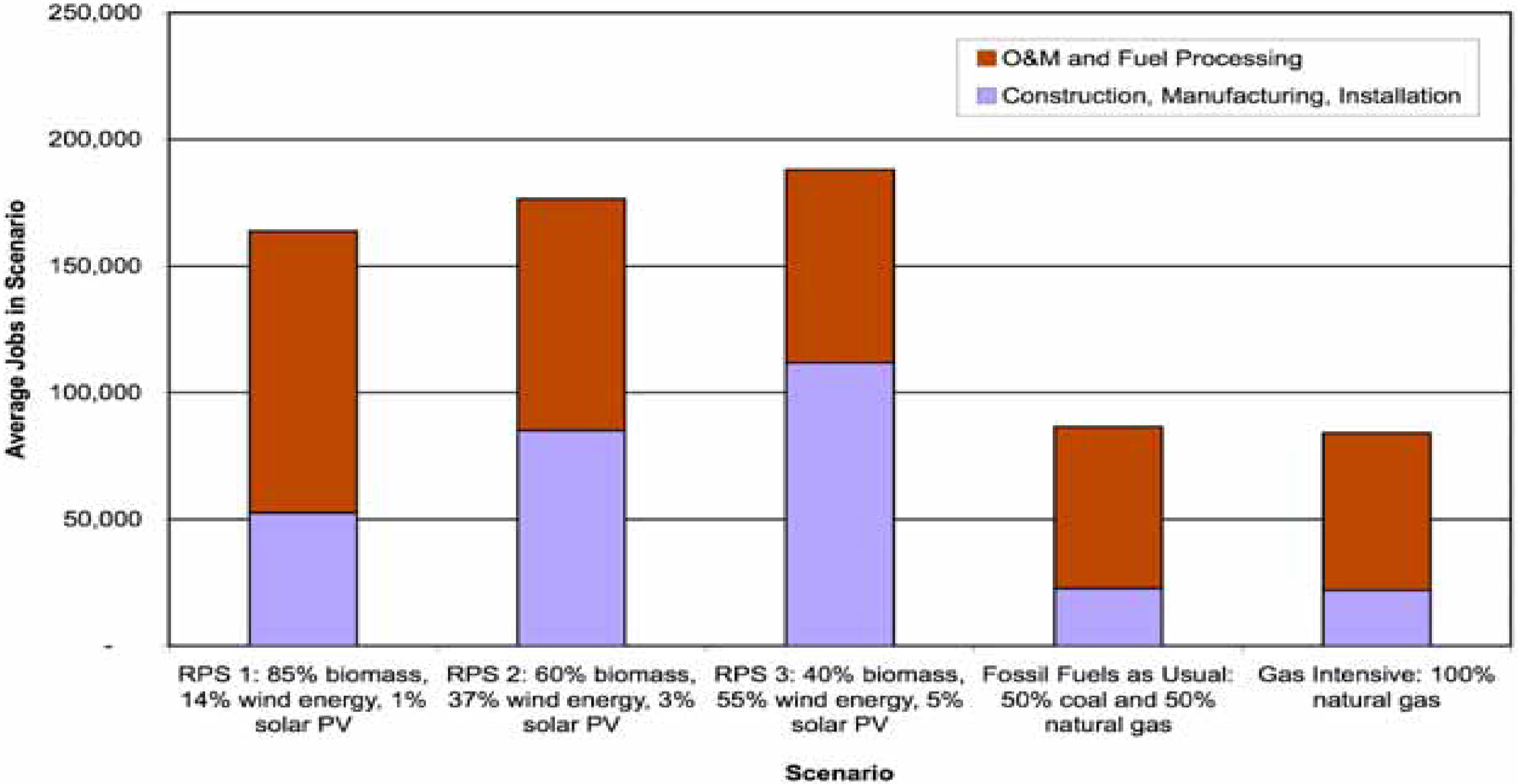
Means More Jobs



Source: Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp (2004) *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? RAEL Report,* University of California, Berkeley.

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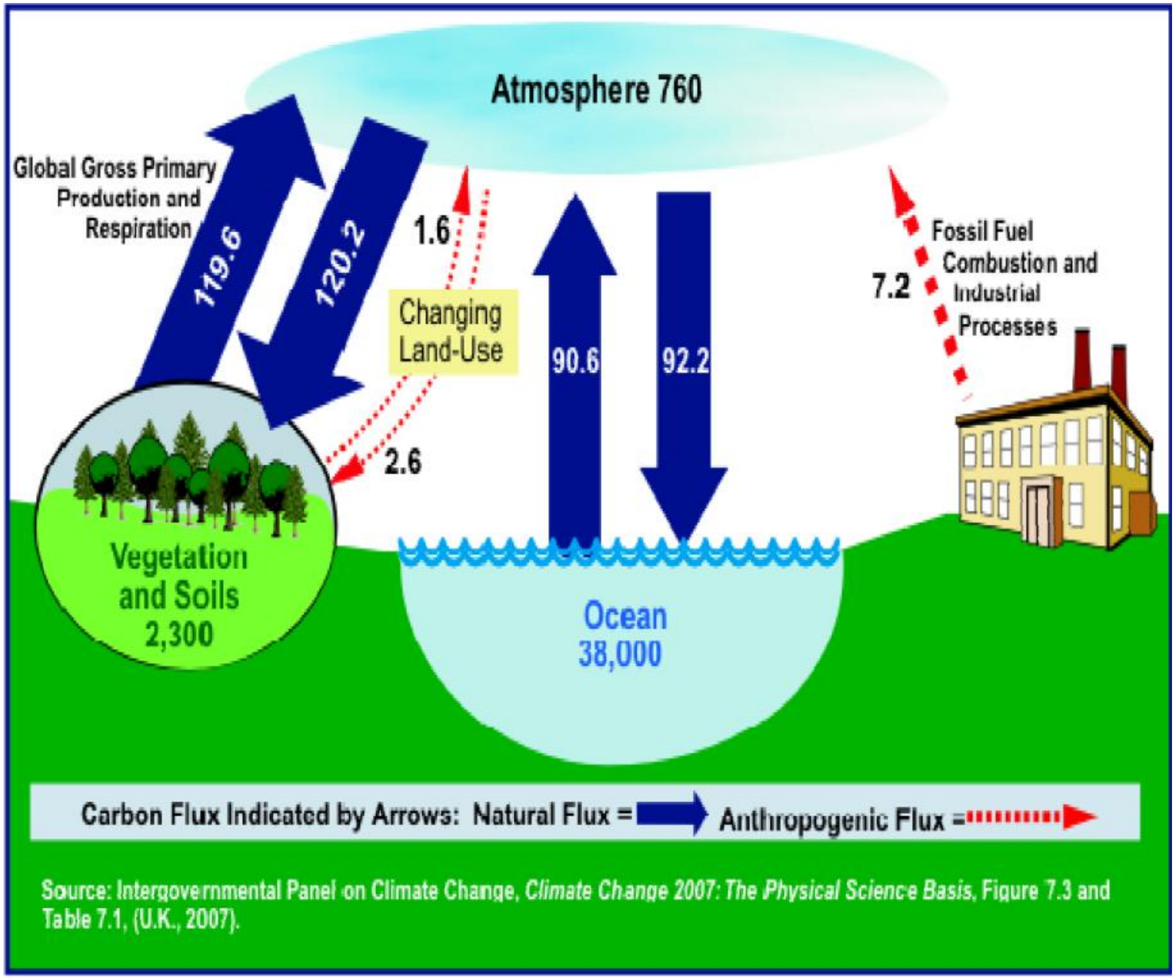
The Carbon Cycle

Emissions by Fuel Type (approximate Pounds of CO_2 per Million Btu)

- Coal => 215
- Oil => 160
- Natural Gas => 115



Source: http://www.eia.doe.gov/bookshelf/brochures/greenhouse/greenhouse.pdf

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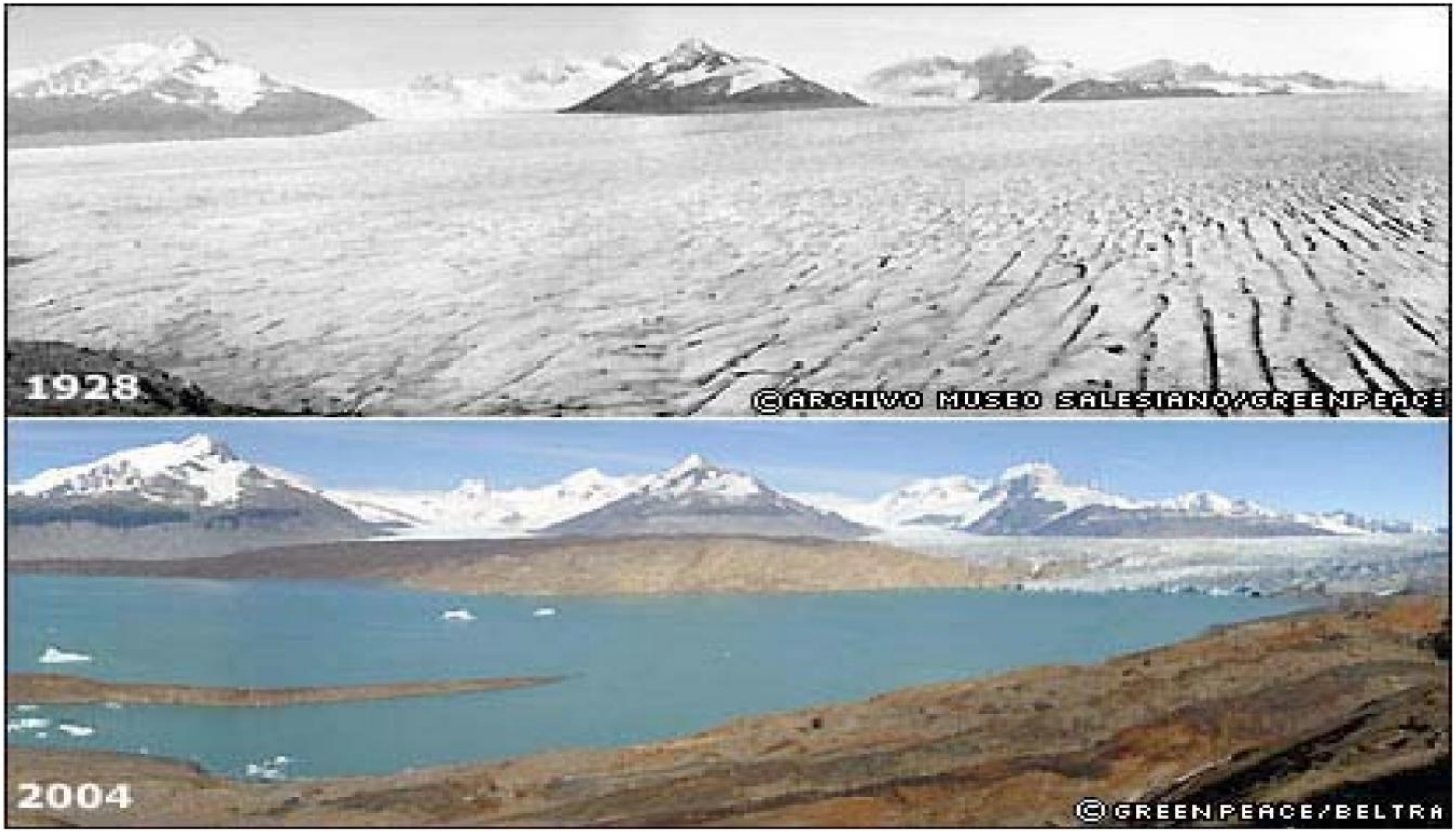
Upsala Glacier, Patagonia, Argentina



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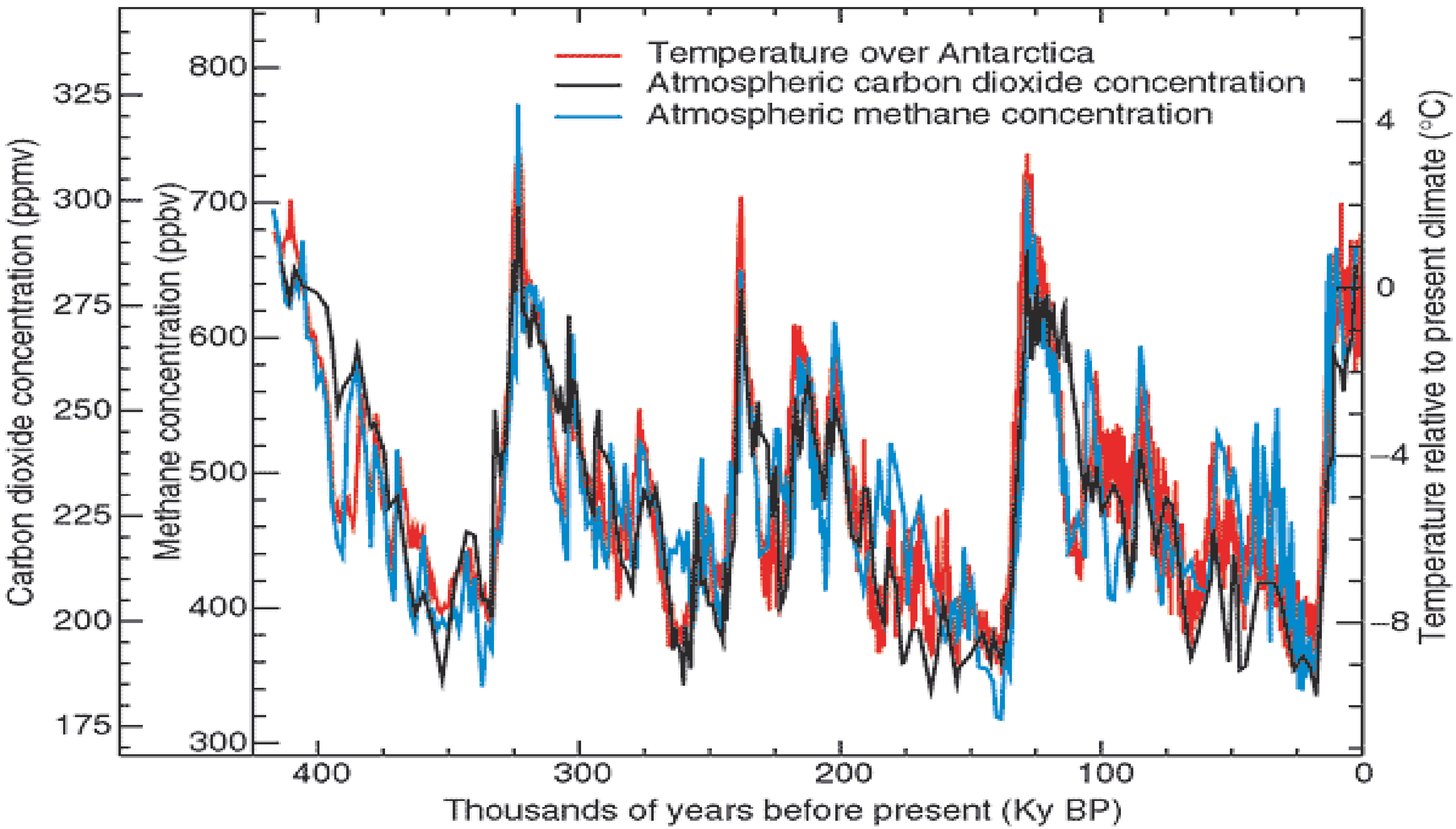
CO_2 AND CH_4 ⇔ Temperature



Source: Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Figure 2.22, http://www.ipcc.ch/ipccreports/assessments-reports.htm

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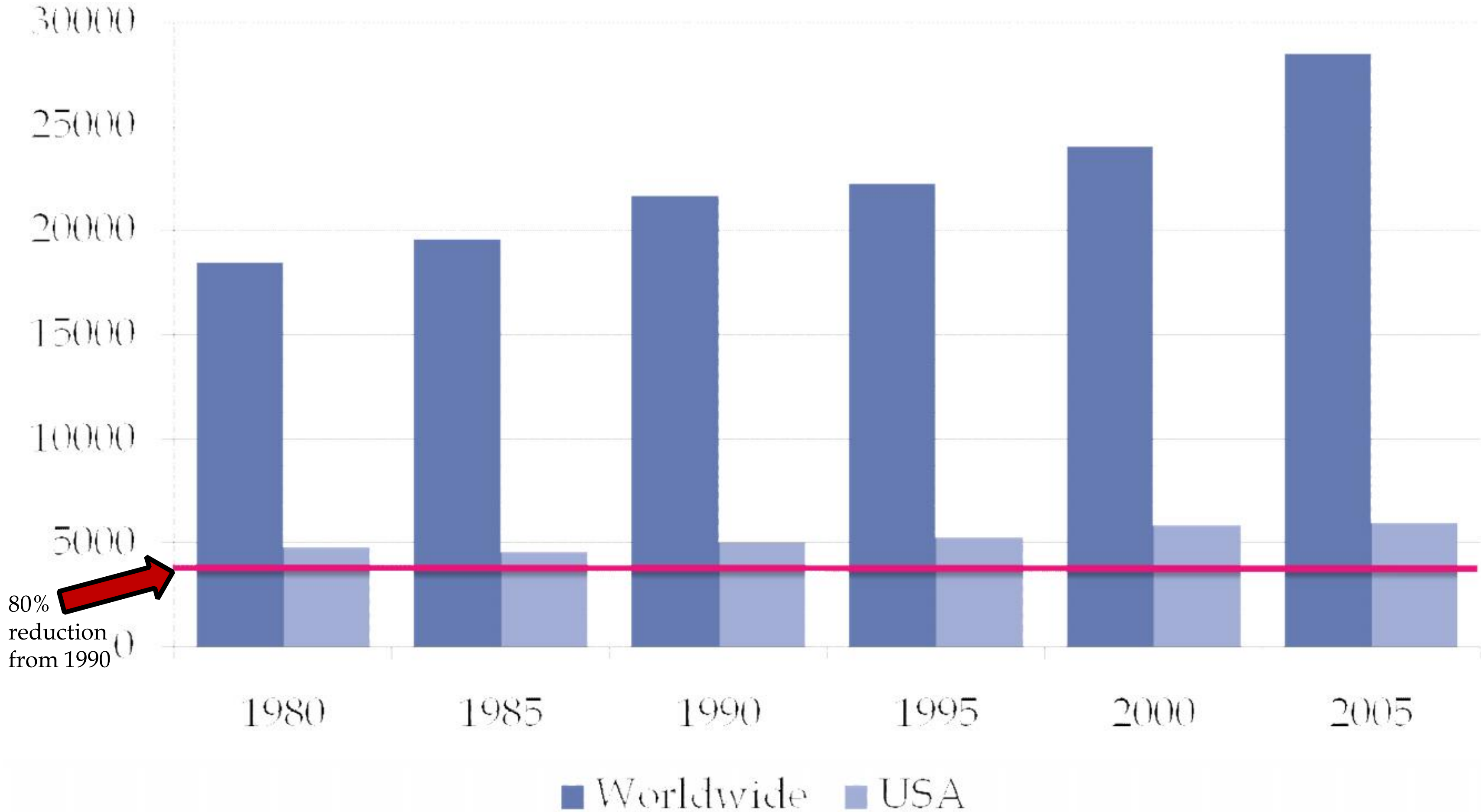
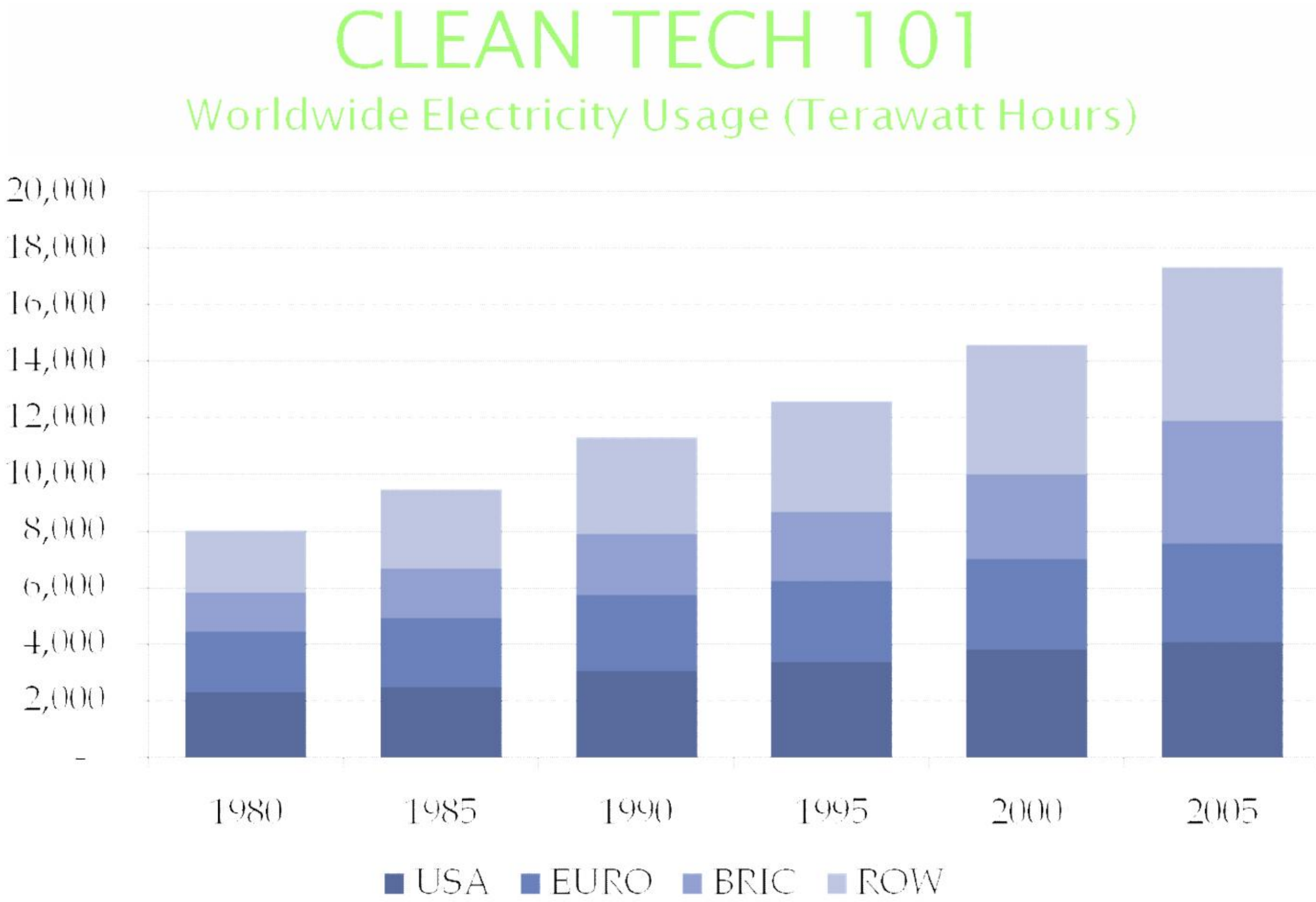
CO_2 Emissions Trend and Target
Million Metric Tons



Source: Energy Information Administration



Source: Energy Information Administration – International Energy Annual 2006

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Electricity Capacity Challenge

- Additional Demand for Terawatt hours
  - 15,000 Terawatt hours by 2030
- Power Plant Sizes
  - Coal => 550 MW at 85% utilization
  - Gas => 400 MW at 87% utilization
  - Nuclear => 1350 MW at 90% utilization
- Add how many for another 15,000 Terawatt hours?
  - Coal => 3,675
  - Gas => 4,925
  - Nuclear => 1,425
- And how fast will you need to build them?
  - Coal => one every 2.5 days
  - Gas => one every 1.8 days
  - Nuclear => one every 6 days

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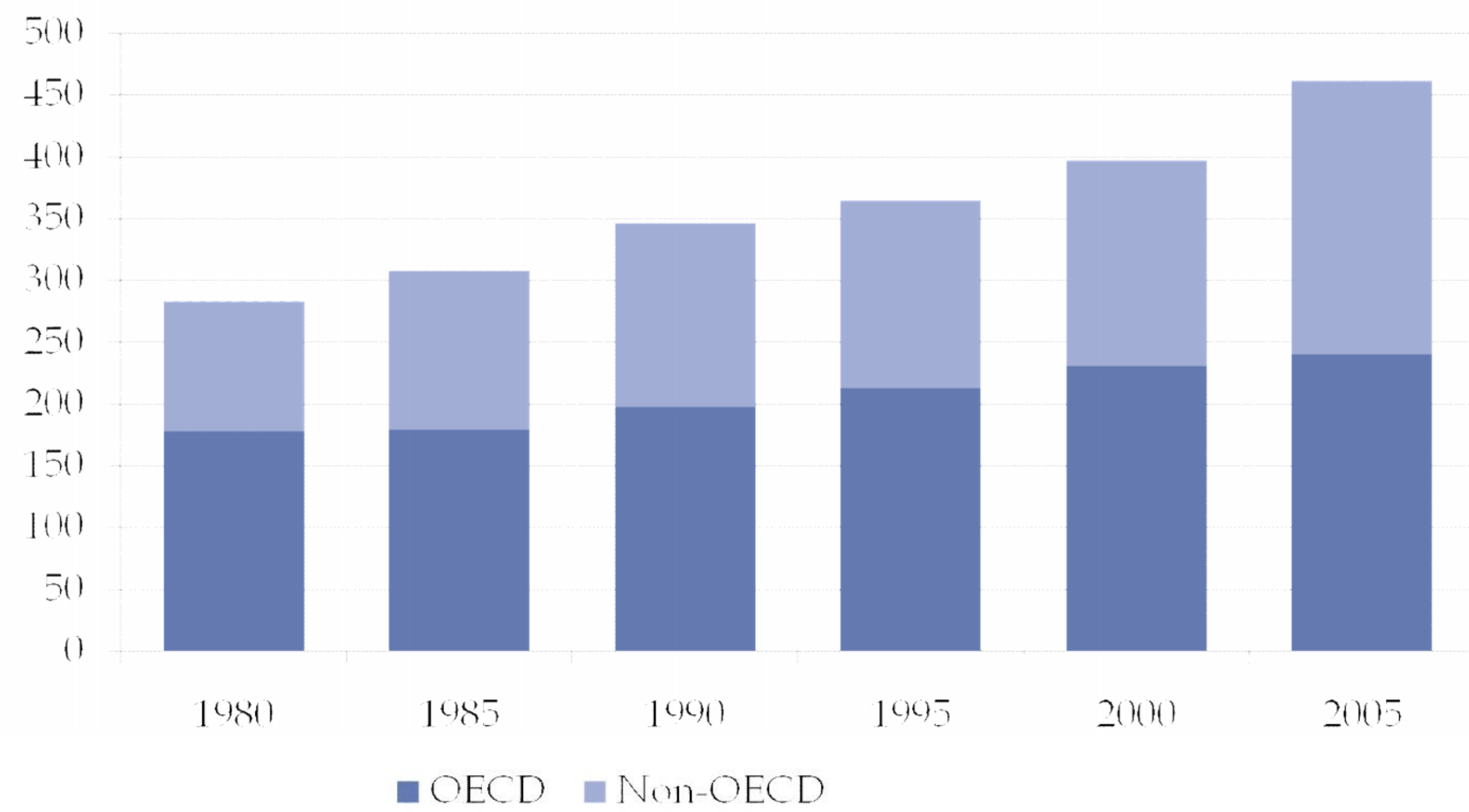
Worldwide Energy Consumption (Quadrillion BTUs)



Source: Energy Information Administration

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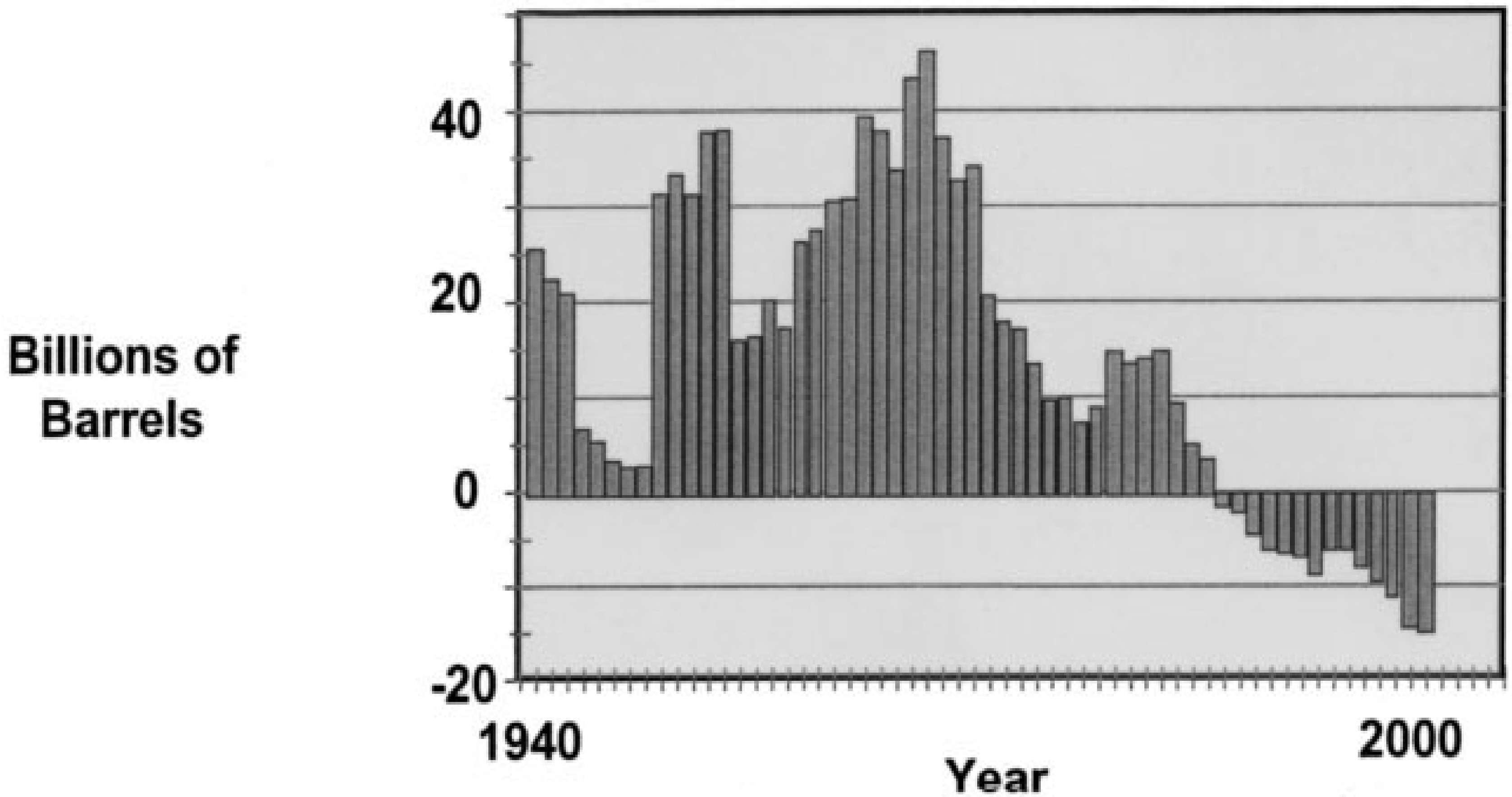
Peaking Oil ⇔ Additions to Reserves Minus Consumption



Source: http://www.hilltoplancers.org/stories/hirsch0502.pdf

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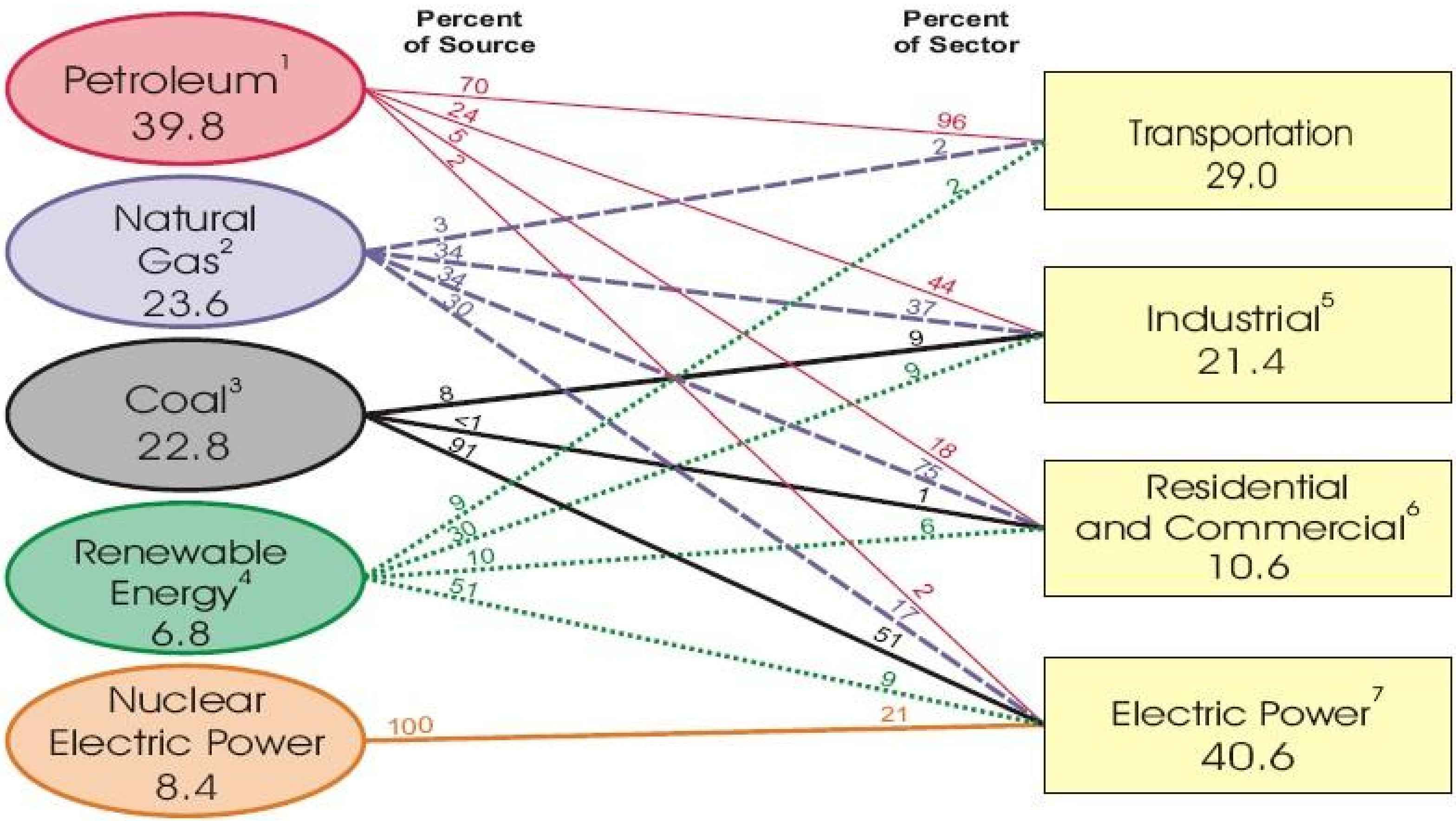
US Primary Energy Use by Source and Sector, 2007 (Quadrillion Btu)



Source: Energy Information Administration – Annual Energy Review 2007

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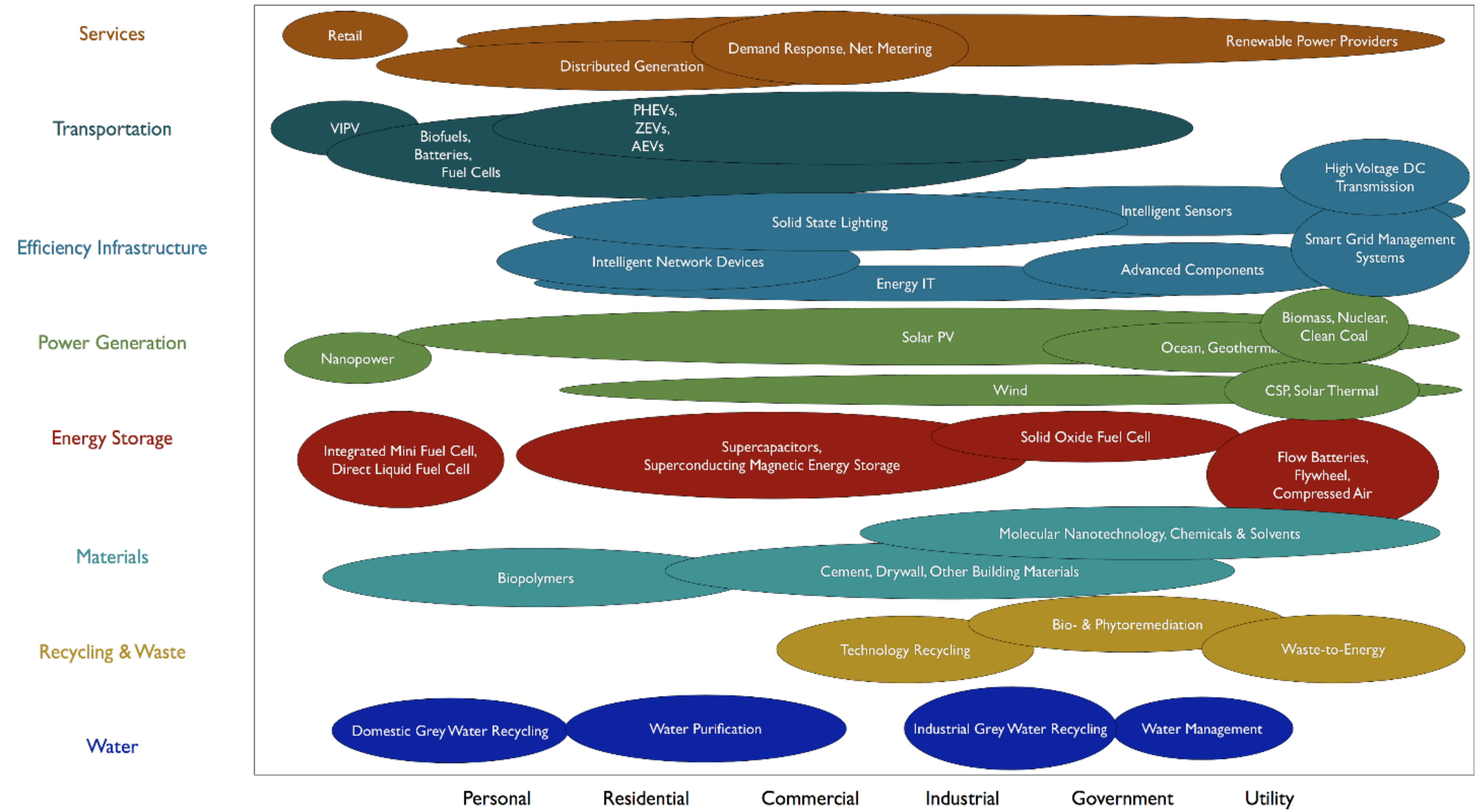
Greentech Media's Market Taxonomy



Source: Greentech Media

www.greentechmedia.com

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Taxonomy Details ⇔ Services

- Renewable Power Providers
  - Renewable power providers own, operate, and finance green power generation sources. These companies partner with systems installers and energy consumers to reduce the risks and costs associated with installing and managing green power generation systems.
  - Examples: SunEdison; Tioga Energy; Solar Power Partners
- Demand Response, Net Metering
  - Demand response service providers monitor consumer demand and scale up or down energy consumption depending on the load requirements of the power grid.
  - Examples: EnerNoc, Inc.; Comverge
- Distributed Generation
  - Distributed generation means skipping around the utilities and power grid and generating power at the point of use. These service providers provide entire packages, including installation, pricing and payment options, ongoing systems maintenance, building permits, and site analysis.
  - Examples: Akeena Solar; SPG Solar; groSolar

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Taxonomy Details ⇔ Retail & Transportation

- Retail
  - Retail stores provide consumers with technical training, installation support and advice, replacement parts for their distributed generation units, system maintenance, and complete systems.
  - Examples: Yes! Solar Solutions
- Transportation
  - PHEVs, ZEVs, AEVs
    - Bringing zero emission vehicles (ZEVs) to commercial scale is dependent on increasing the storage capacity of batteries while decreasing their size and weight, increasing the availability of fuel for fuel cells, and producing carbon neutral biofuels on a level equivalent to gasoline.
    - Examples: A123Systems; Sion Power; Ballard Power Systems; Iroquois Bio-Energy Company; Farmacule BioEnergies; LS9
  - Biofuels, Batteries, Fuel Cells
    - Green vehicles rely on a variety of power sources such as batteries, fuel cells, and biofuels. While the industry is ultimately moving towards zero emissions vehicles, plug-in hybrids and partial emissions are a necessary step along the way.
  - VIPV
    - Vehicle integration of PV cells to provide complete power is a long way off. However, a niche consumer industry has developed to begin providing this technology as a supplement to ZEVs and PHEVs.

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Taxonomy Details ⇔ Efficiency Infrastructure

- High Voltage DC Transmission
  - Expanding the grid to accept the growing variety of green power generation sources requires building and deploying better transmission equipment. Also, greening the power markets means making green power generation accessible to everyone, everywhere. This can only be accomplished through updates and enhancements to power grid equipment and infrastructure.
- Smart Grid Management Systems
  - Integrated communication through broadband-bearing power lines will allow for real-time data transfer and efficient asset allocation, load switching, and monitoring of multiple power sources feeding into the grid.
  - Examples: Optimal Technologies International, Inc.; Fat Spaniel; Broadband Energy Networks
- Intelligent Sensors
  - Intelligent sensors are programmable devices that monitor and regulate the use of electricity, lighting, water, HVAC, fertilizer, and almost any other resource needed for integrated systems operations.
  - Examples: GoodCents; SensiNet
- Advanced Components
  - New generations of superconductive cables and power electronics will facilitate the increased load demand and increasing variety of power sources taking advantage of the smart grid.
  - Examples: Echelon Corp.
- Energy IT
  - Energy IT software identifies energy waste in electrical or networking systems and prescribes ways to eliminate it. More advanced software automates the waste-reduction process, and works to optimize the distribution of energy around the system.
  - Examples: Verdiem; Optimal Technologies International, Inc.
- Solid State Lighting
  - Using light emitting diodes are a high intensity, low heat, and low power light source compared to filaments or gas. Solid state lighting is easily modifiable in color, shade, and intensity.
- Intelligent Network Devices
  - Intelligent devices installed in homes and businesses that monitor energy production and consumption serve both the needs of both homeowners and utilities.
  - Examples: Comverge; GridPoint

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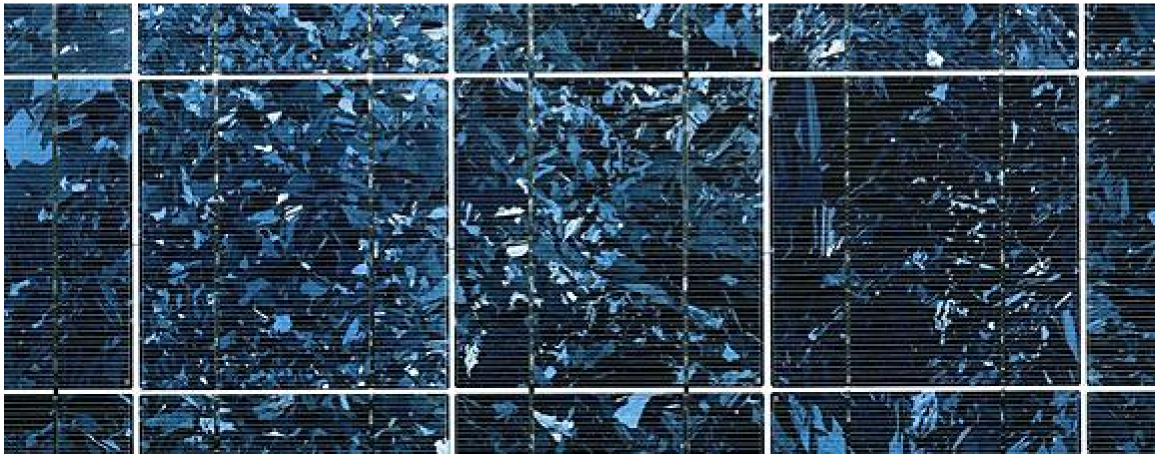
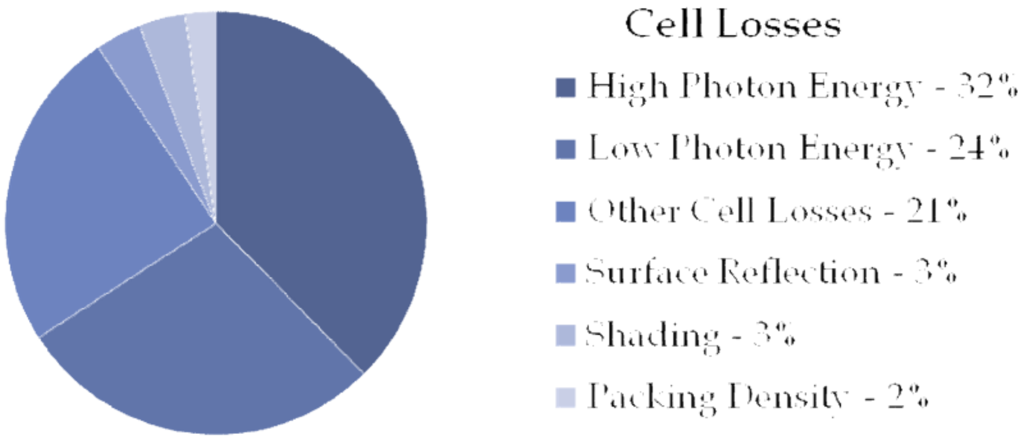
Solar PV is 15% Efficient



Empowered: Detail of a solar panel built with crystalline PV cells from Q-Cells, the world's largest manufacturer. | photograph by Charles Masters



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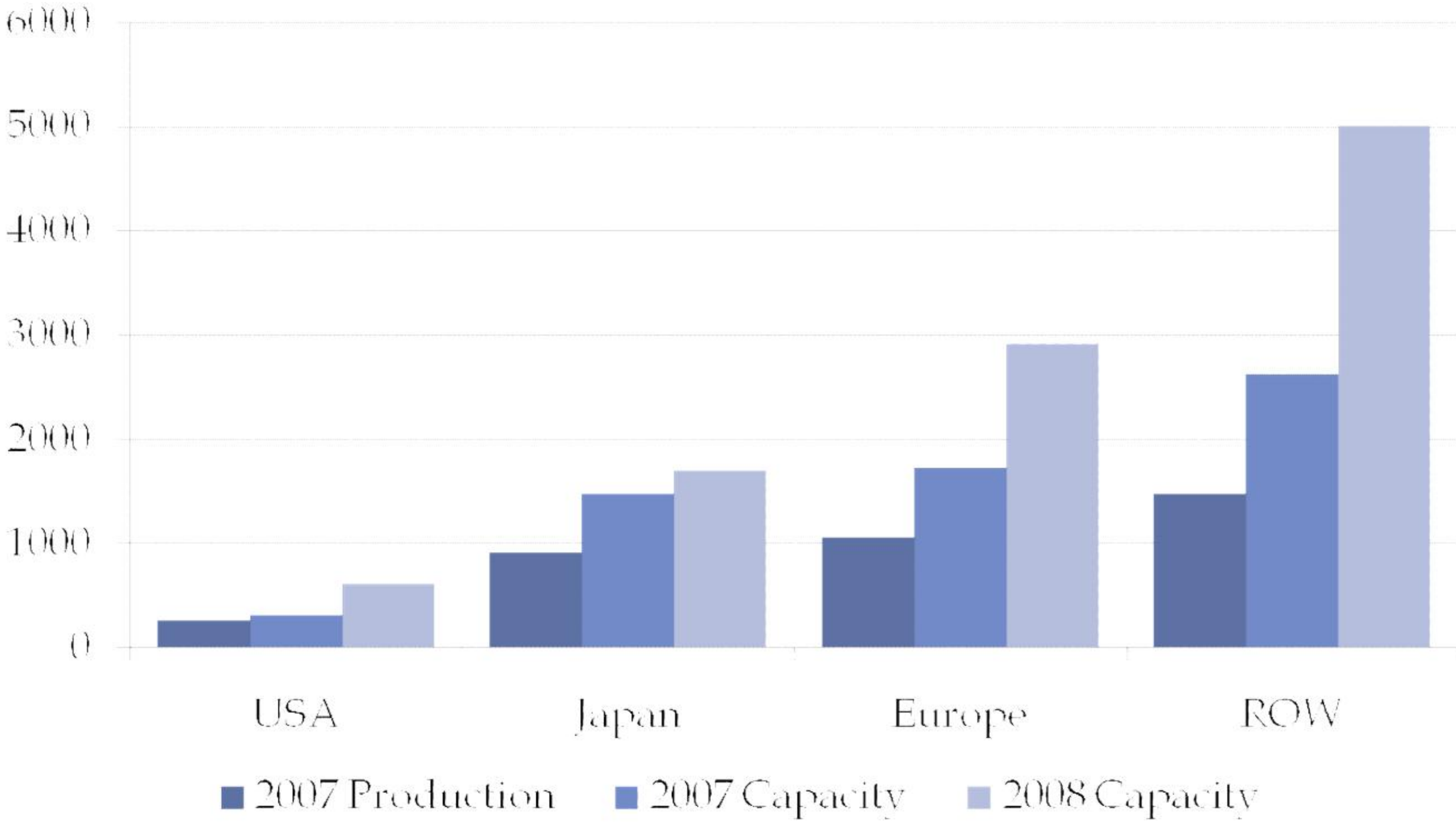
Solar Production and Capacity (MW-dc)



Source: *PVNews™ March 2008*

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Prometheus Institute

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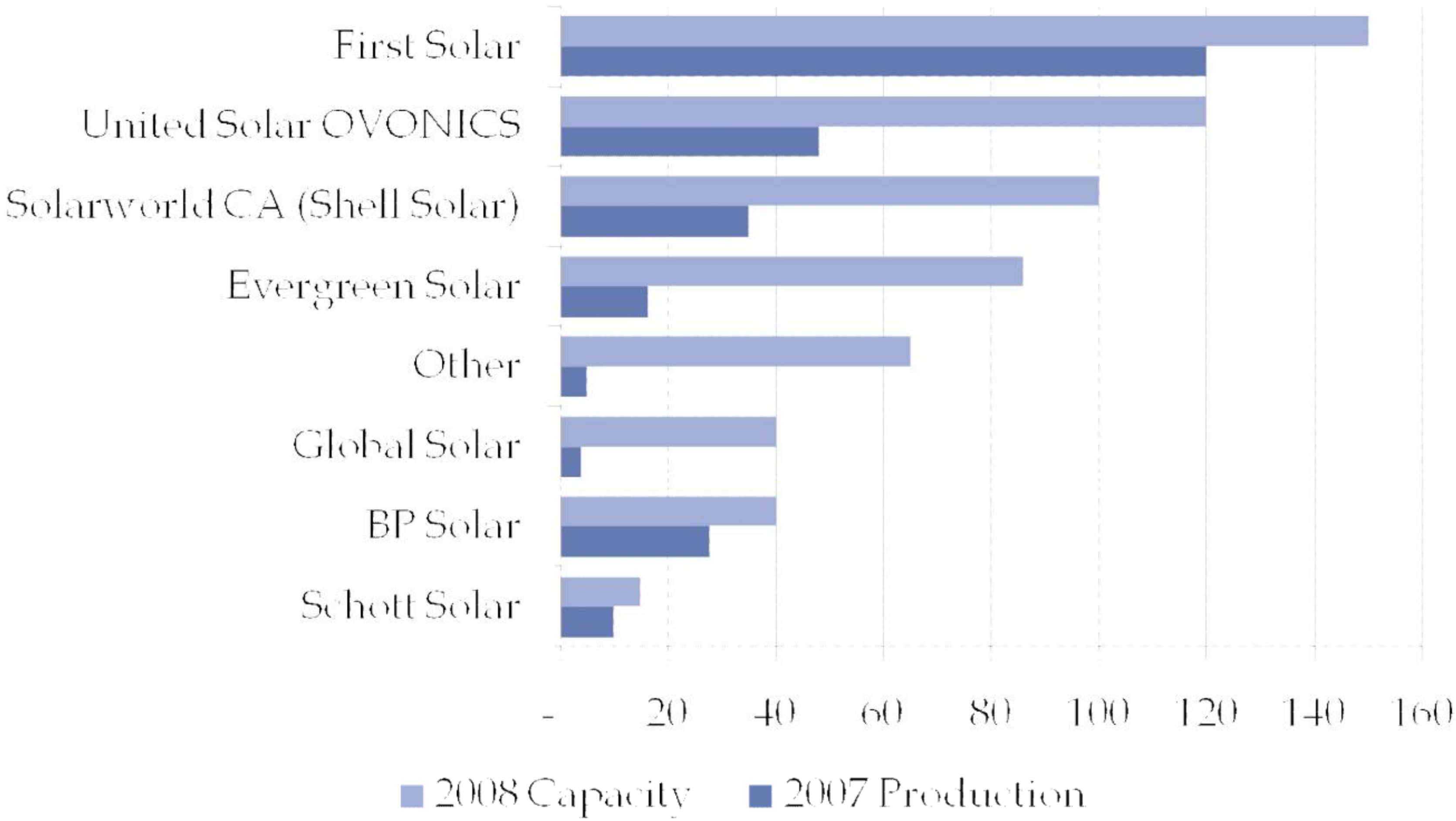
US Solar Production and Capacity (MW-dc)



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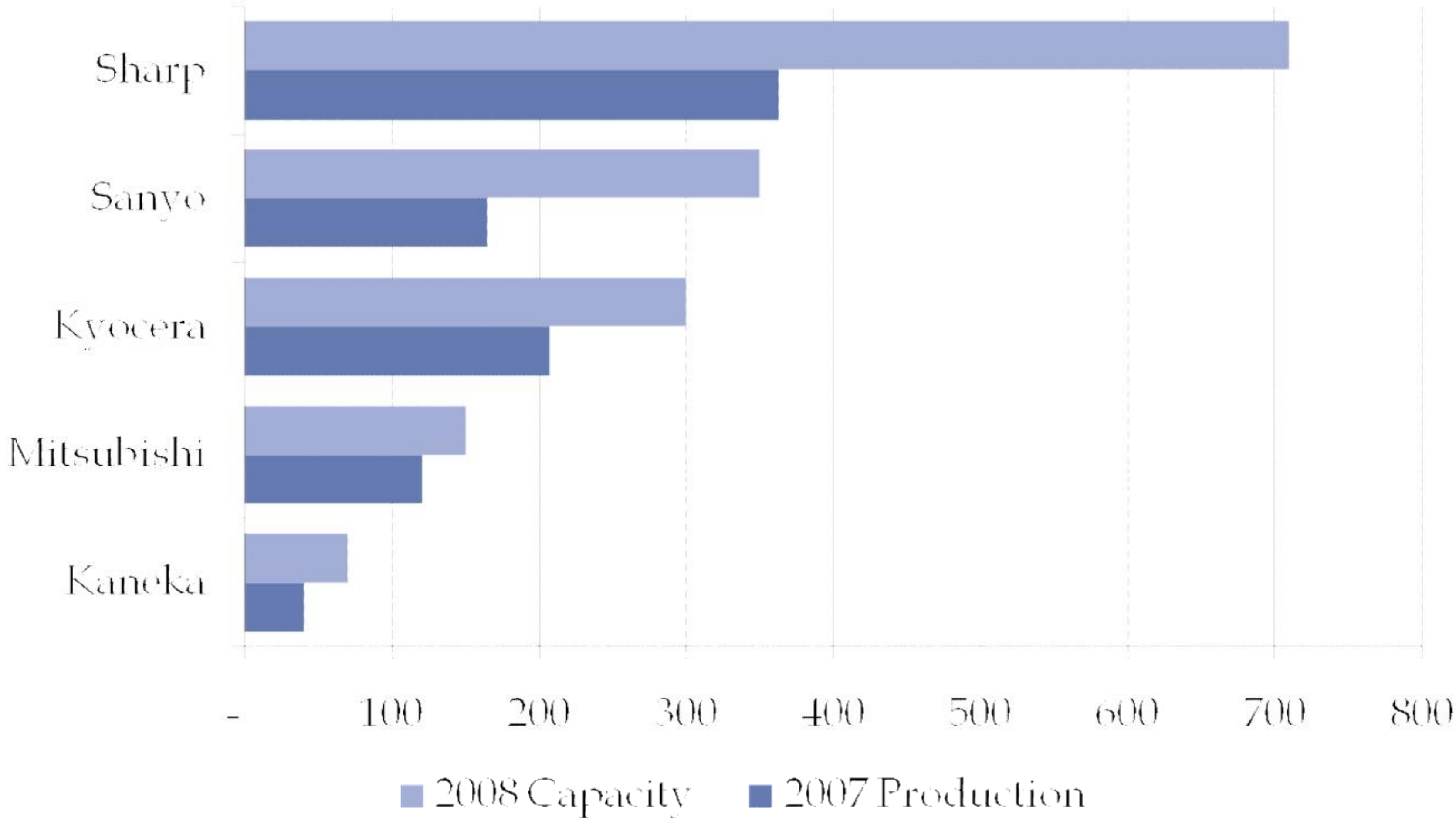
Japan Solar Production and Capacity (MW-dc)



Source: *PVNews™ March 2008*

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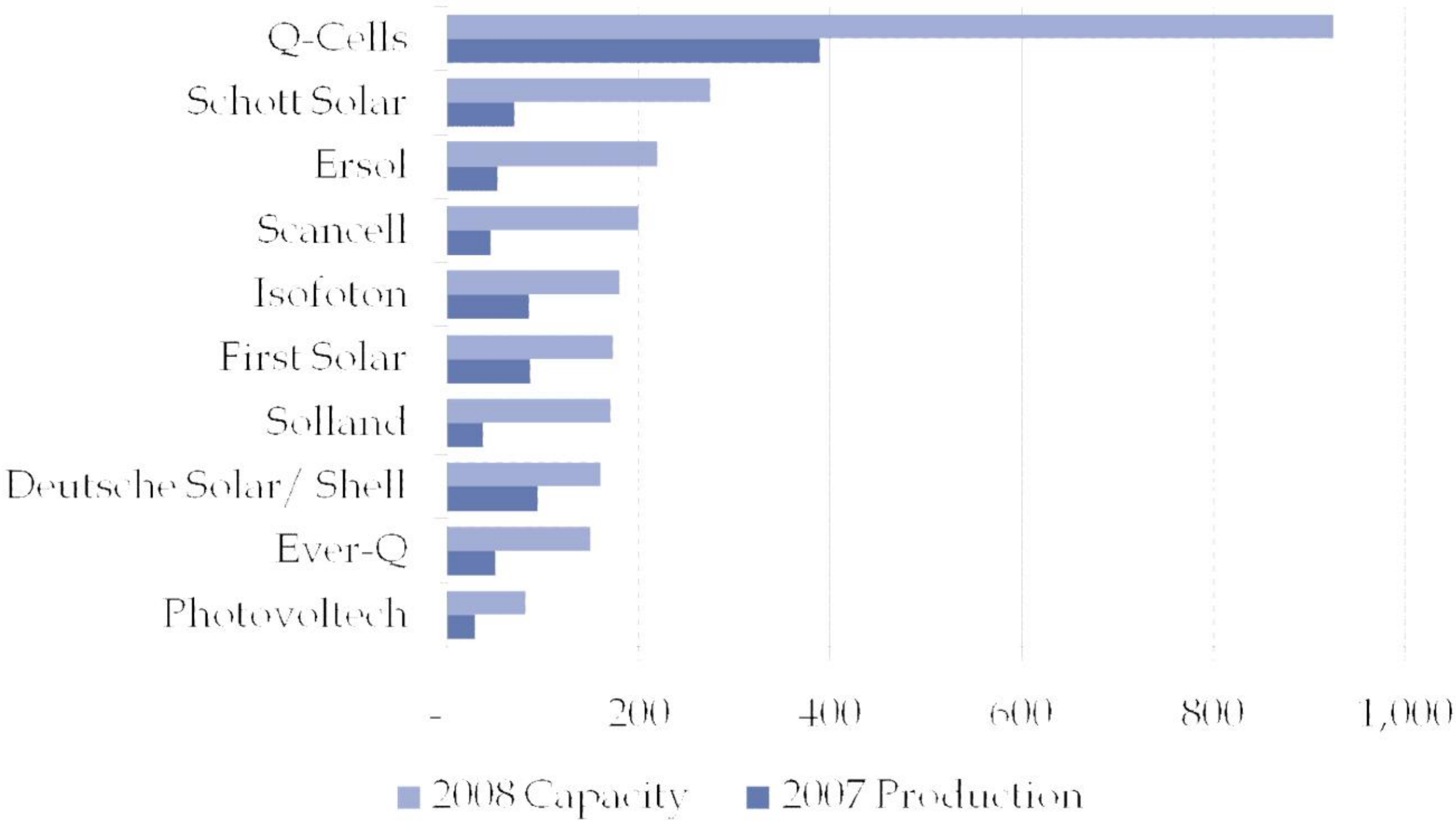
Europe Solar Production and Capacity (MW-dc)



Source: *PVNews™ March 2008*

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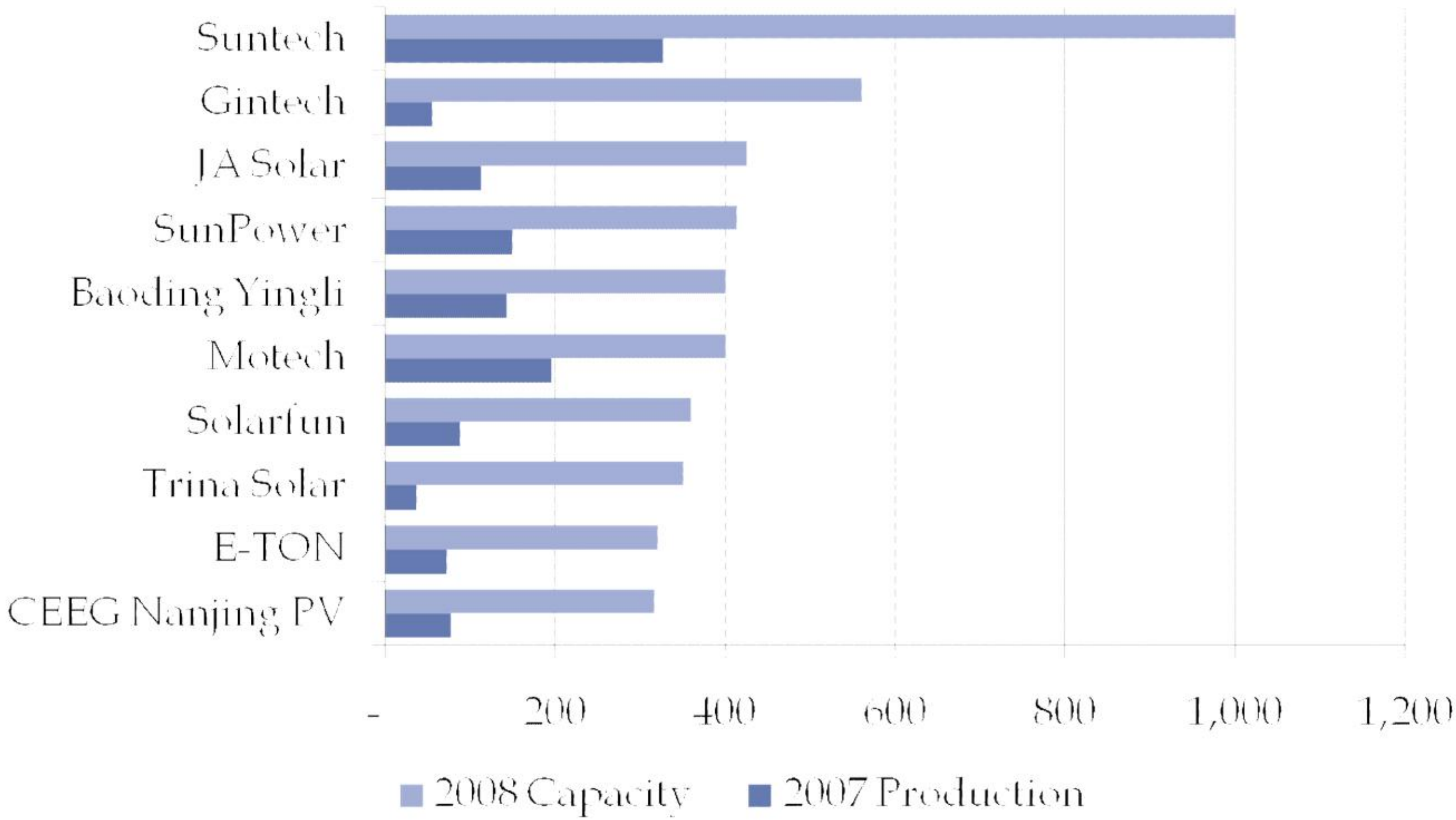
ROW Solar Production and Capacity (MW-dc)



Source: *PVNews™ March 2008*

greentechmedia: Prometheus Institute

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Thin Film PV

	Material Type	Absorber Layer	Substrate	Process	Companies
Thin Film Solar	Silicon	Amorphous Silicon	Flexible	CVD	*Unisolar, PowerFilm, Flexcell, Xunlight*
			Rigid	CVD	*EPV, Kaneka, Mitsubishi, Sharp, Optisolar*
		Other Thin Silicon	Flexible	Printing	*Innovalight*
			Rigid	CVD	*CSG Solar, Octilion, Soltaix, Nanogram*
	Non-Silicon	CdTe	Rigid	CVD	*First Solar, Calyxo, Primestar, AVA Tech, Arendi*
		CIGS	Flexible	Printing	*Nanosolar*
				Co-Evaporation	*Ascent Solar, Global Solar, Flisom, Solarion*
				Electroplating	*Solo Power*
				Sputtering	*Miasole'*
			Rigid	Co-Evaporation	*Wuerth Solar, ISET*
				Sputtering	*Avancis, Johanna, Daystar, Honda, Showa shell, Sunvin, Solyndra, Sulfurcell*
				Printing	*Heliovolt*
		Organic/DSC	Flexible	Printing	*G24i, Konarka, Plextronics, Solarmer*

Source: Prometheus Institute

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Solar PV Companies in North America

1366 Technologies	Advent Solar	Ascendant Energy	Ascent Solar	AVA Solar	Bandgap Engineering	Bloo Solar/Q1 Nanosystems	Blue Square Energy	CaliSolar
CIS Solar	Cool Earth Solar	Crown Renewable Energy	Cyrium Technologies	Day4Energy	DayStar Technologies	Energy Innovations	Enfocus Engineering	EPOD Solar
Evergreen Solar	First Solar	Gamma Solar	Global Solar	Green Brilliance	GreenField Solar/Photovolt	Greenvolts	Heliovolt	Innovalight
JX Crystals	Konarka	Lambda Energia S.A.	Miasolé	MicroLink Devices	Morgan Solar	Nanosolar	Nanosys	NewCyte
Octillion	OneSun	Opel International	Optisolar/Gen 3 Solar	Pacifi c Solartech	Photovoltaic Solar Cells Inc.	Plextronics	PrimeStar Solar	Prism Solar Technologies
Pyron Solar	SBM Solar	Sencera	Sierra Solar Power	Signet Solar	Silicon Valley Solar/NuEdison	Solar Fields	Solar Power Industries	Solaria
Solarmer	Solasta/The Eagle Axis	SolBeam	Solexant	SolFocus	Soliant Energy	SoloPower	Soltaix/Solexel	Solyndra
Stellaris	Stion/Nstructures	Sun Phocus	Suniva	SVV Technology Innovations	Vanguard Solar	Wakonda Technologies	XsunX	Xunlight/MWOE Solar

Source: GREENTECH INDETAIL NOVEMBER 2008

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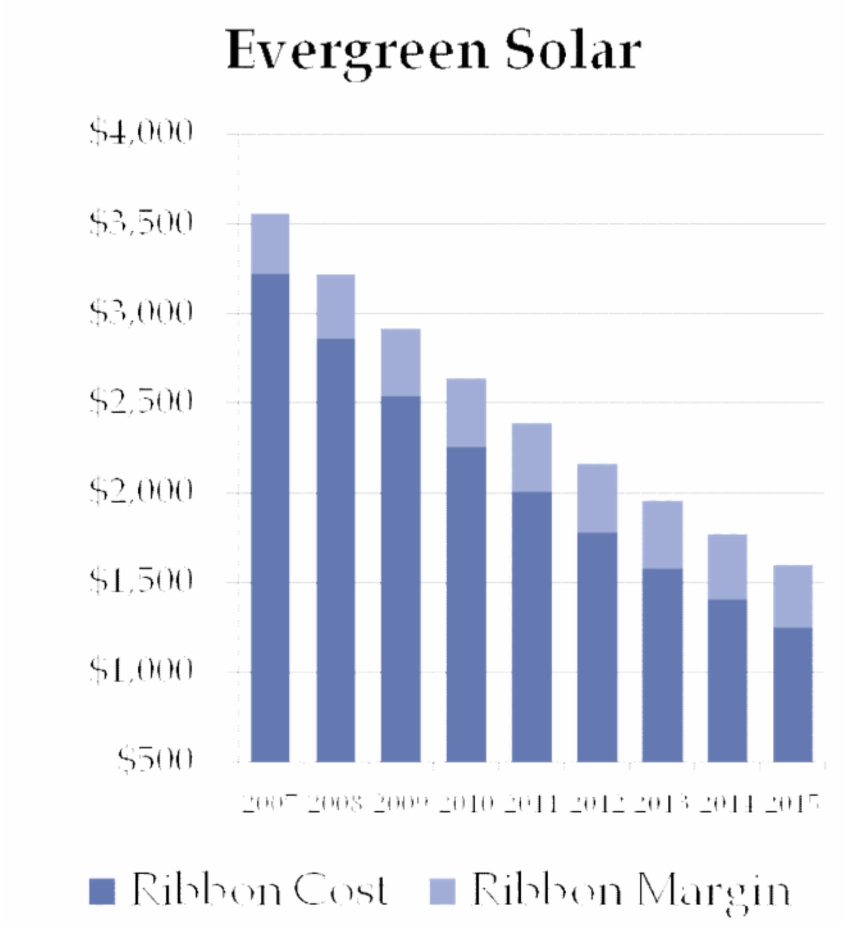
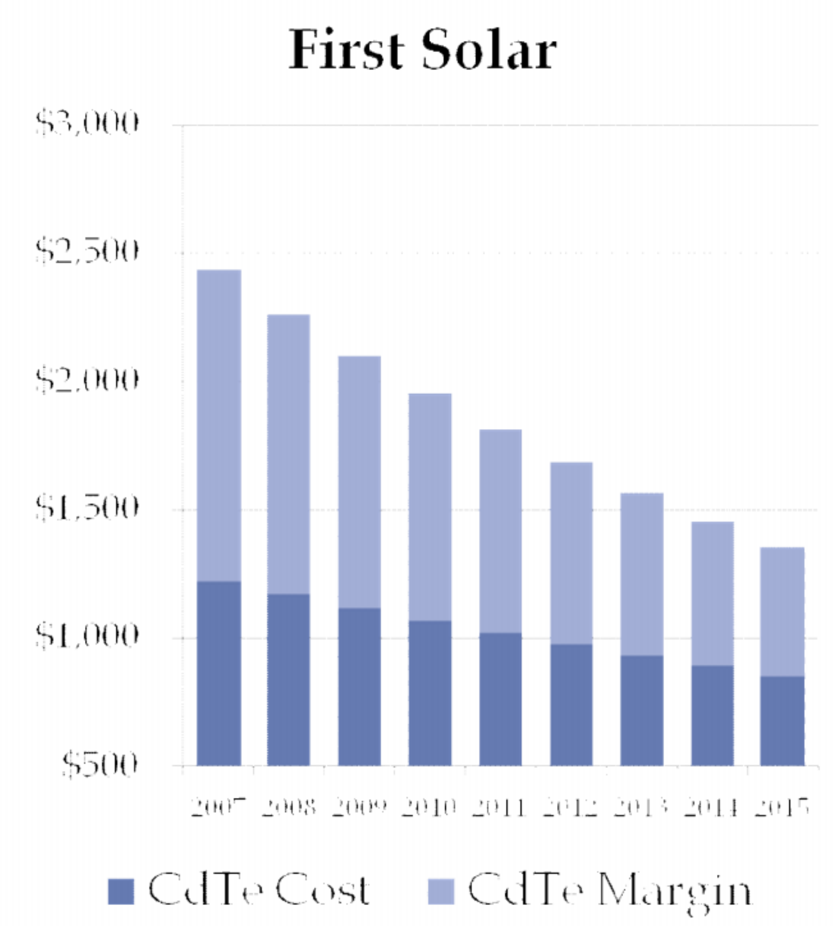
Solar Module Cost Trends ($/kWp)





Sources: Prometheus Institute; PV News; Evergreen 10K; First Solar 10K

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Don't Forget Balance of Systems Costs

Installed Cost ($/kWp)	C-Silicon	Thin Film
Modules	$ 3,557	$ 2,435
Substructure, Installation	$ 390	$ 859
DC-Cabling	$ 146	$ 334
Inverters	$ 341	$ 668
Engineering	$ 292	$ 334
Other	$ 146	$ 143
Total	$ 4,873	$ 4,775

Source: Phoenix Solar AG – numbers derived using percentages of module cost for balance of systems costs as reported by Phoenix; Module costs for Evergreen Solar and First Solar

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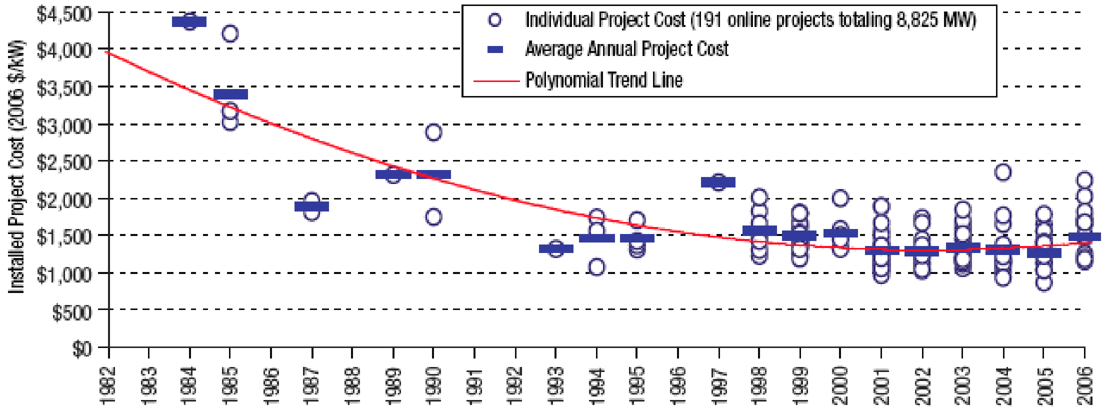
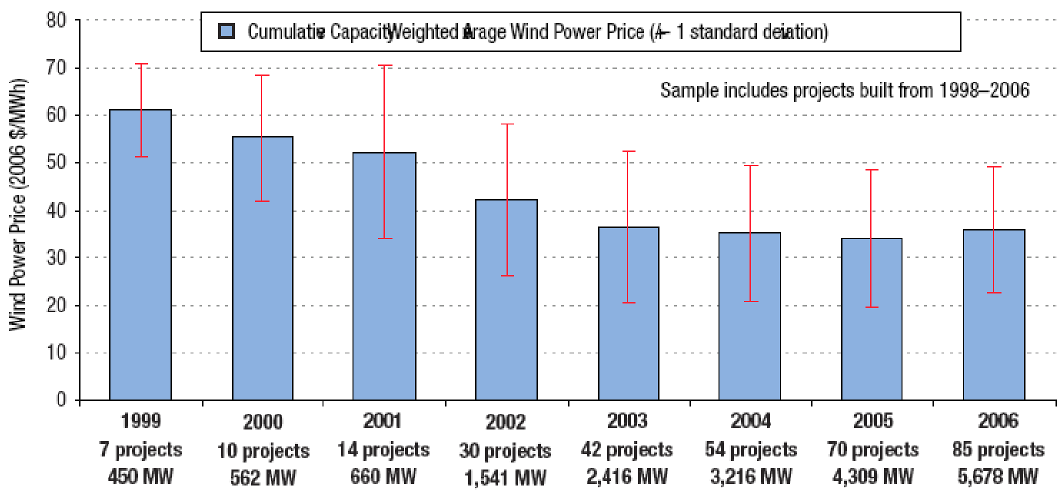
Wind Power Costs



Source: Berkeley Lab database (some data points suppressed to protect confidentiality).



Source: Berkeley Lab database.

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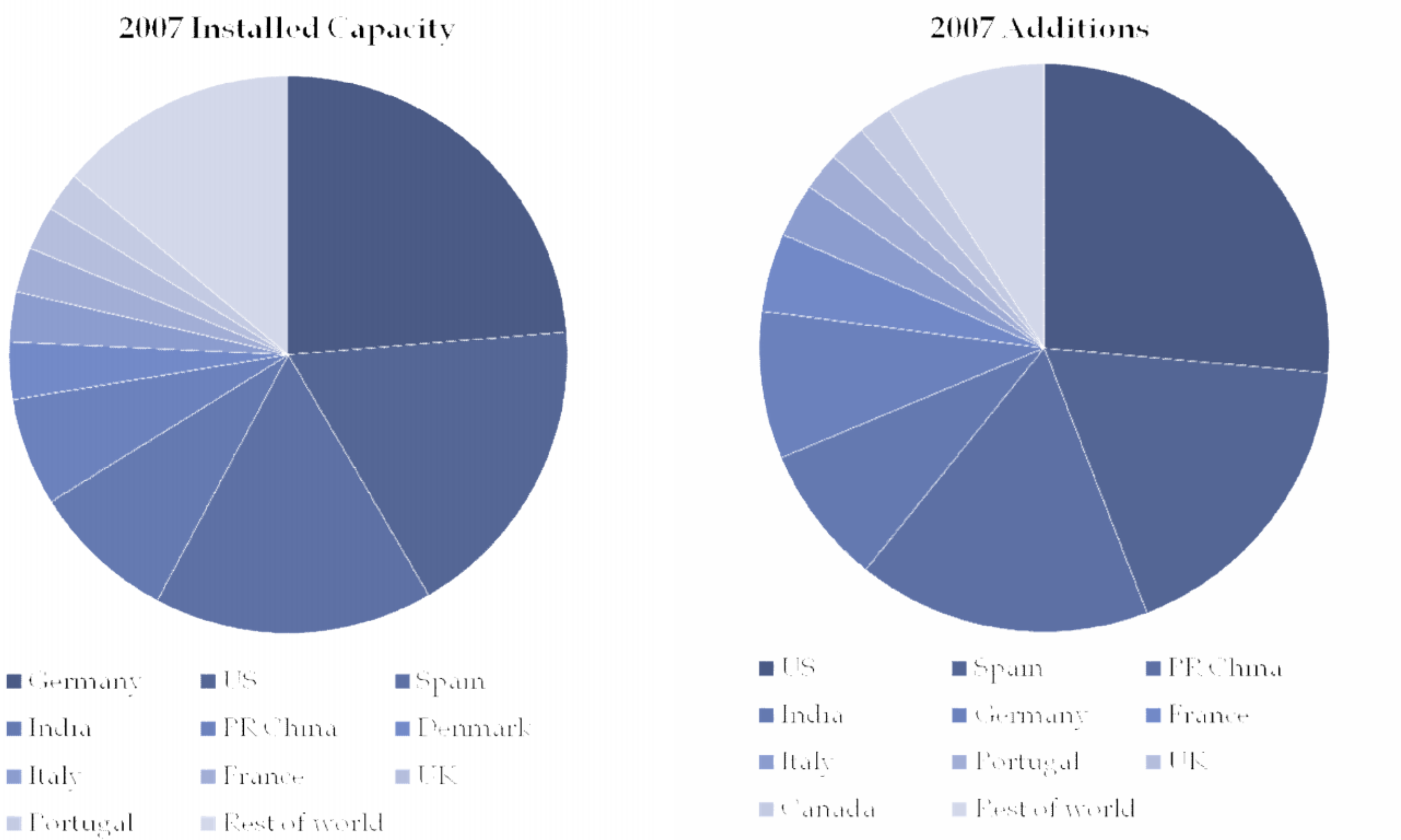
Capacity by Country



Source: Global Wind Energy Council – Global Wind 2007 Report

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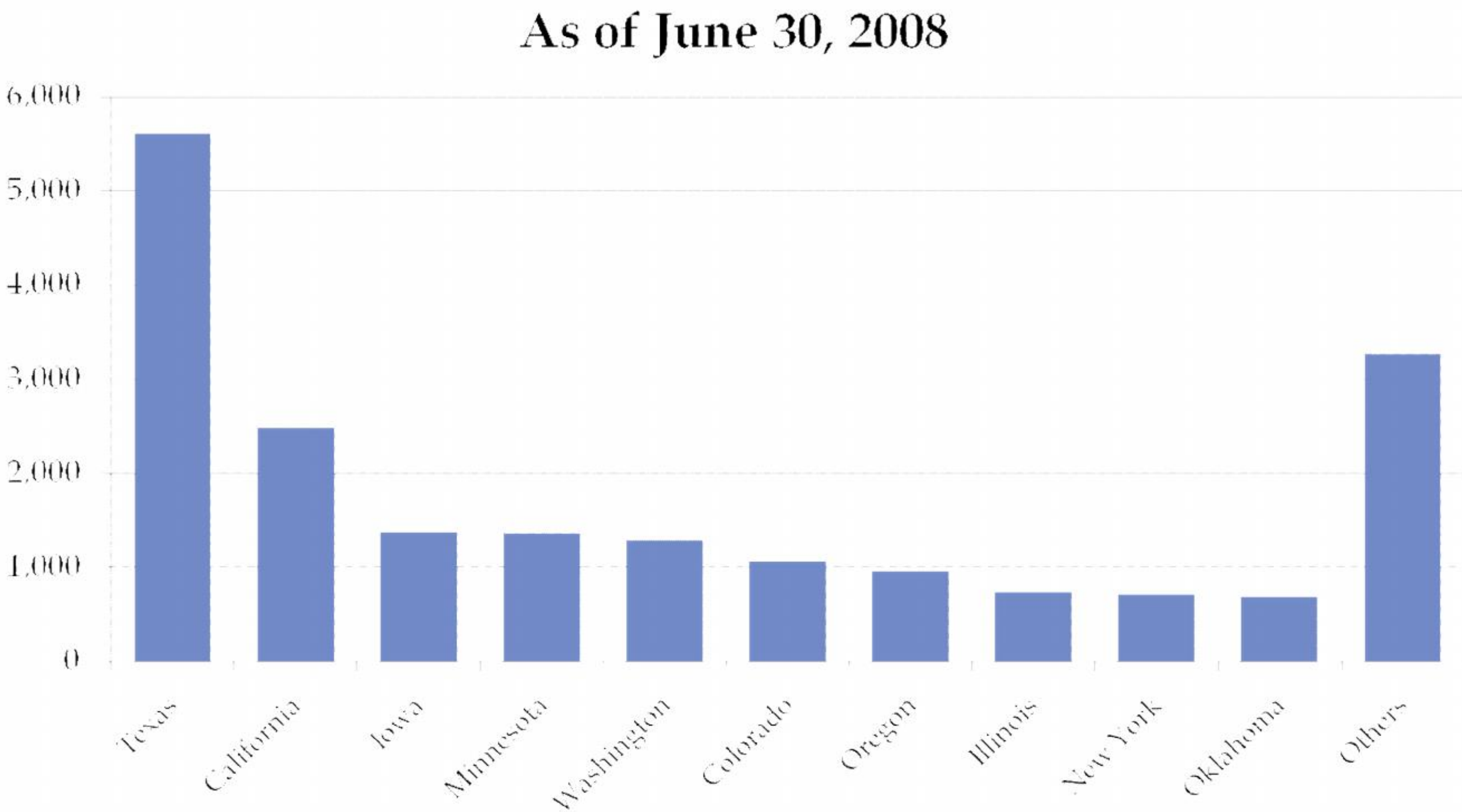
US Installed Capacity ⇔ Top Ten States (Total = 19,548 MW)



Source: AWEA as reported by Global Wind Energy Council – Global Wind 2007 Report

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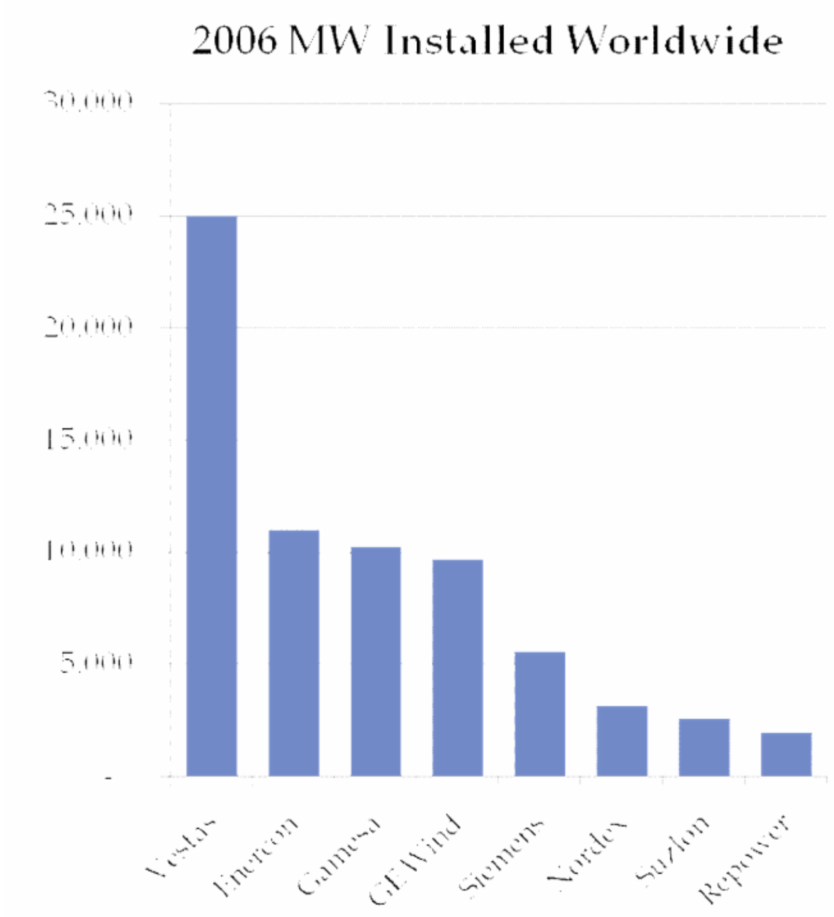
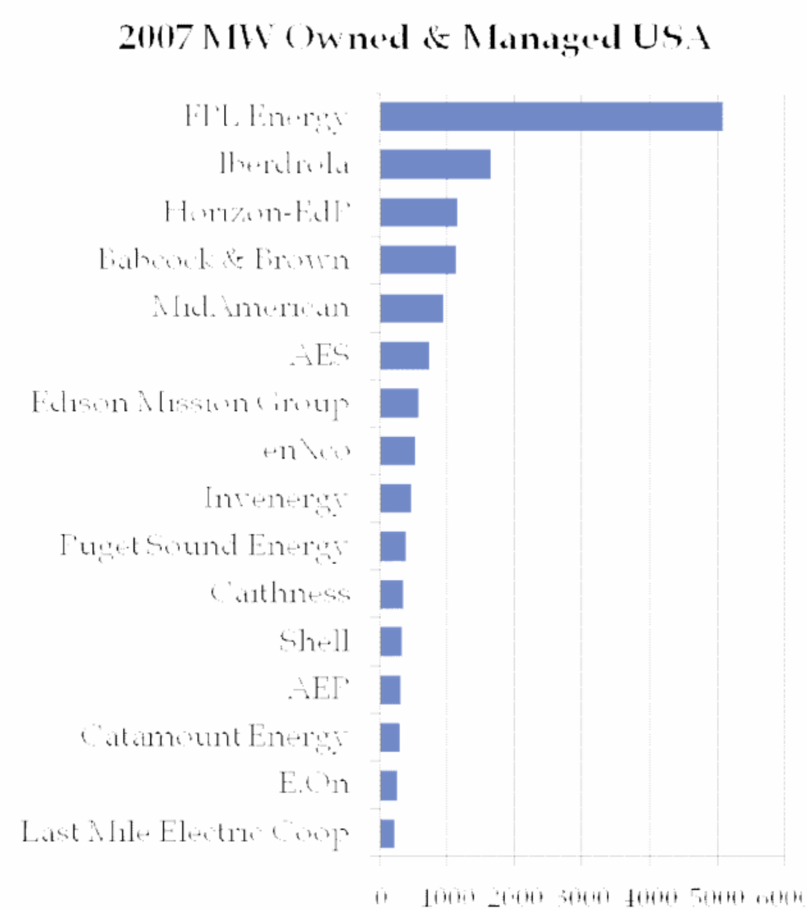
Some Rankings in Wind Energy



Source: Merrill Lynch



Source: American Wind Energy Association
Annual Rankings Report April 2008

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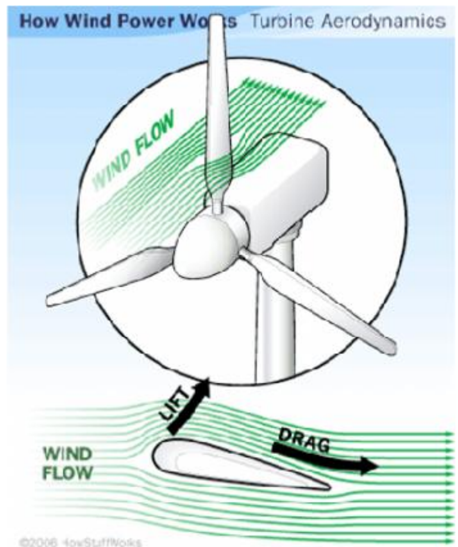
Megawatt Scale Wind Turbines

Above: Vestas V90 3MW Turbine



Right: Clipper Liberty C96 2.5MW Turbine

Source: Abigail Krich, President, Boreas Renewables, LLC

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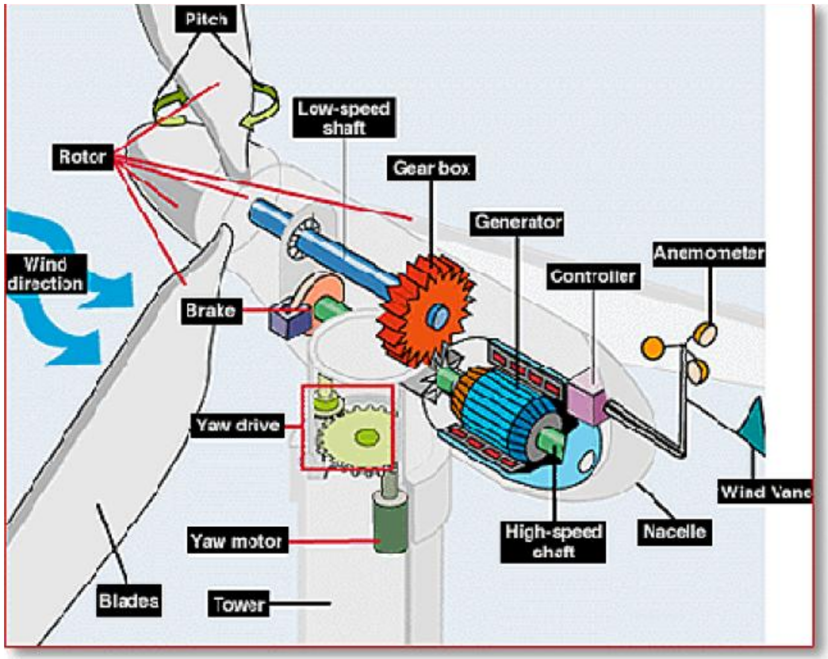
How Wind Turbines Work



- **Anemometer:**
  - Measures the wind speed and transmits wind speed data to the controller.
- **Blades:**
  - Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.
- **Brake:**
  - A disc brake, which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.
- **Controller:**
  - The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.
- **Gear box:**
  - Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.
- **Generator:**
  - Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.
- **High-speed shaft:**
  - Drives the generator.
- **Low-speed shaft:**
  - The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.
- **Nacelle:**
  - The nacelle sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.
- **Pitch:**
  - Blades are turned, or pitched, out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.
- **Rotor:**
  - The blades and the hub together are called the rotor.
- **Tower:**
  - Towers are made from tubular steel (shown here), concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
- **Wind direction:**
  - This is an "upwind" turbine, so-called because it operates facing into the wind. Other turbines are designed to run "downwind," facing away from the wind.
- **Wind vane:**
  - Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.
- **Yaw drive:**
  - Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.
- **Yaw motor:**
  - Powers the yaw drive.

Source: http://www1.eere.energy.gov/windandhydro/wind_how.html#inside

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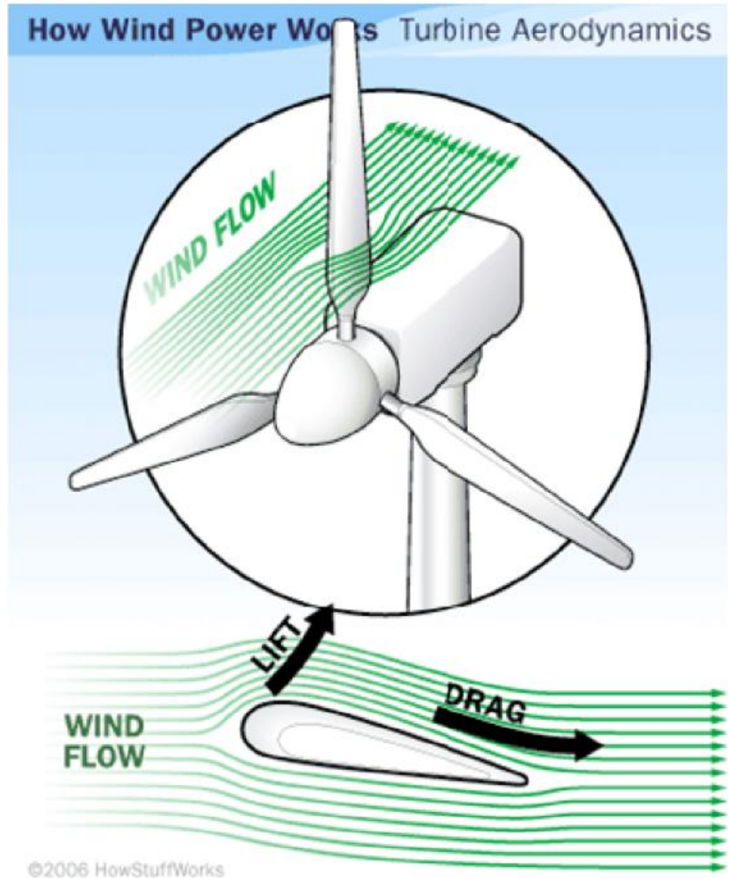
Megawatt Scale Wind Turbines

Above: Vestas V90 3MW Turbine



Source: Presentation by Abigail Krich, President, Boreas Renewables, LLC

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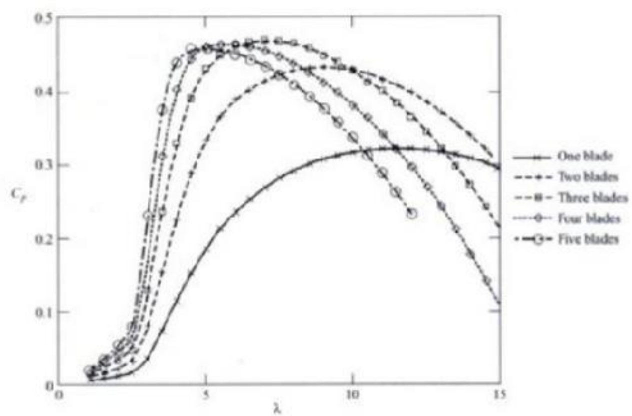
Wind Power Technology Quantified

- Power output from a wind turbine - $P = \frac{1}{2}\rho A V^3 C_p$
  - Max C_p theoretical limit is .593
  - Drag device limit is .16
  - Lift range is between .25 and .45 for modern turbines
- Ratio of blade tip speed to wind speed – $\lambda = \frac{\omega R}{V}$
  - λ = tip speed ratio
  - ω = angular frequency
  - R = rotor radius
  - V = wind speed



Source: Presentation byAbigail Krich, President, Boreas Renewables, LLC

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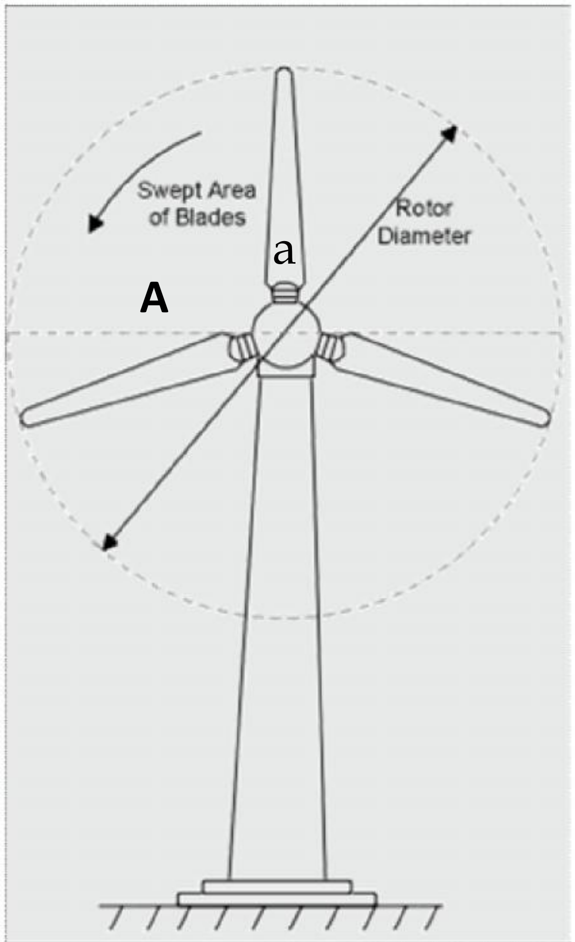
Rotor Solidity



- Rotor Solidity is a/A
  - a is the blade area
  - A is the swept area
- Higher solidity
  - Higher torque (higher gearbox costs)
  - Higher thrust (higher tower costs)
  - Higher rotor material costs

Source: Presentation byAbigail Krich, President, Boreas Renewables, LLC

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3 Bladed Machines

- Balance between
  - High C_p
  - Sensitivity to tip speed ratio
  - Cost driven by solidity
- Visually appealing

Right: Clipper Liberty C96 2.5MW Turbine
Note: Technology team for Clipper Wind founded Zond which was acquired by Enron Wind and is now GE Wind

Source: Presentation by Abigail Krich, President, Boreas Renewables, LLC

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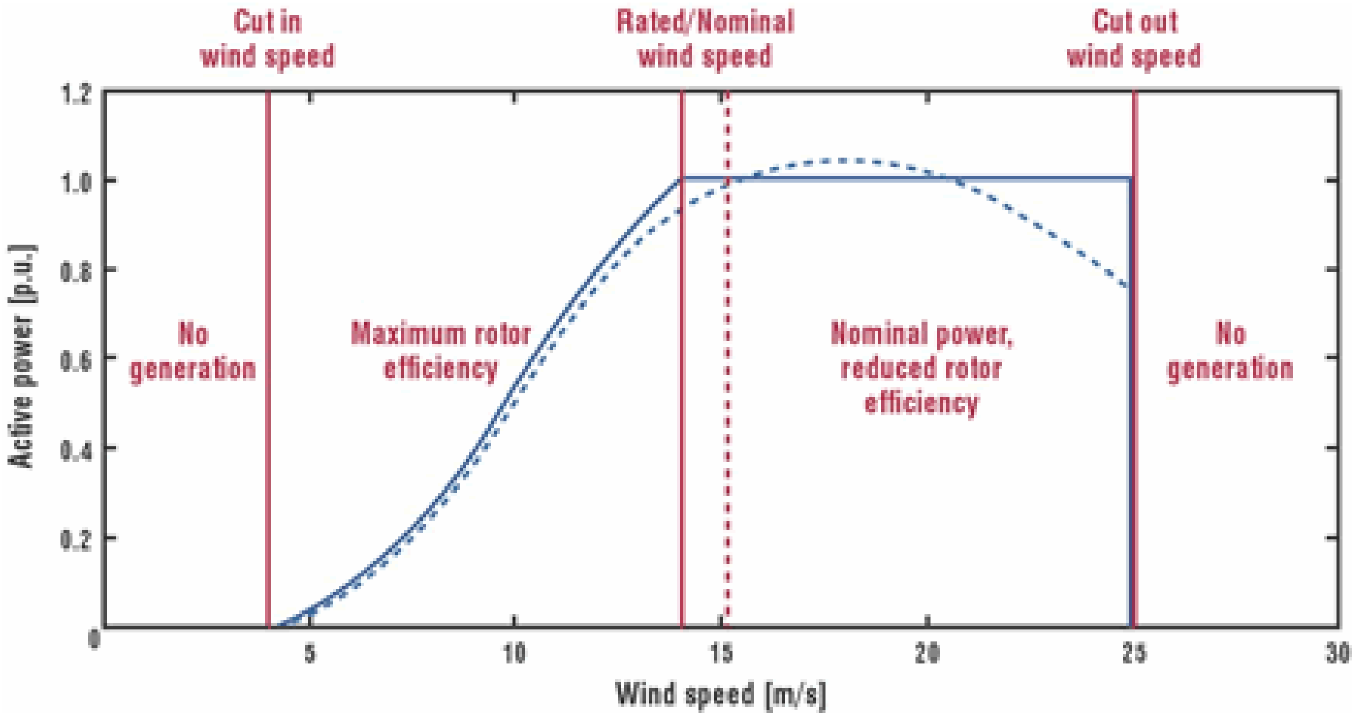
Wind Turbine Performance *f*(Wind Speed)



Source: EWEA, Merrill Lynch
http://www.wavesecurities.biz/media/81290.pdf

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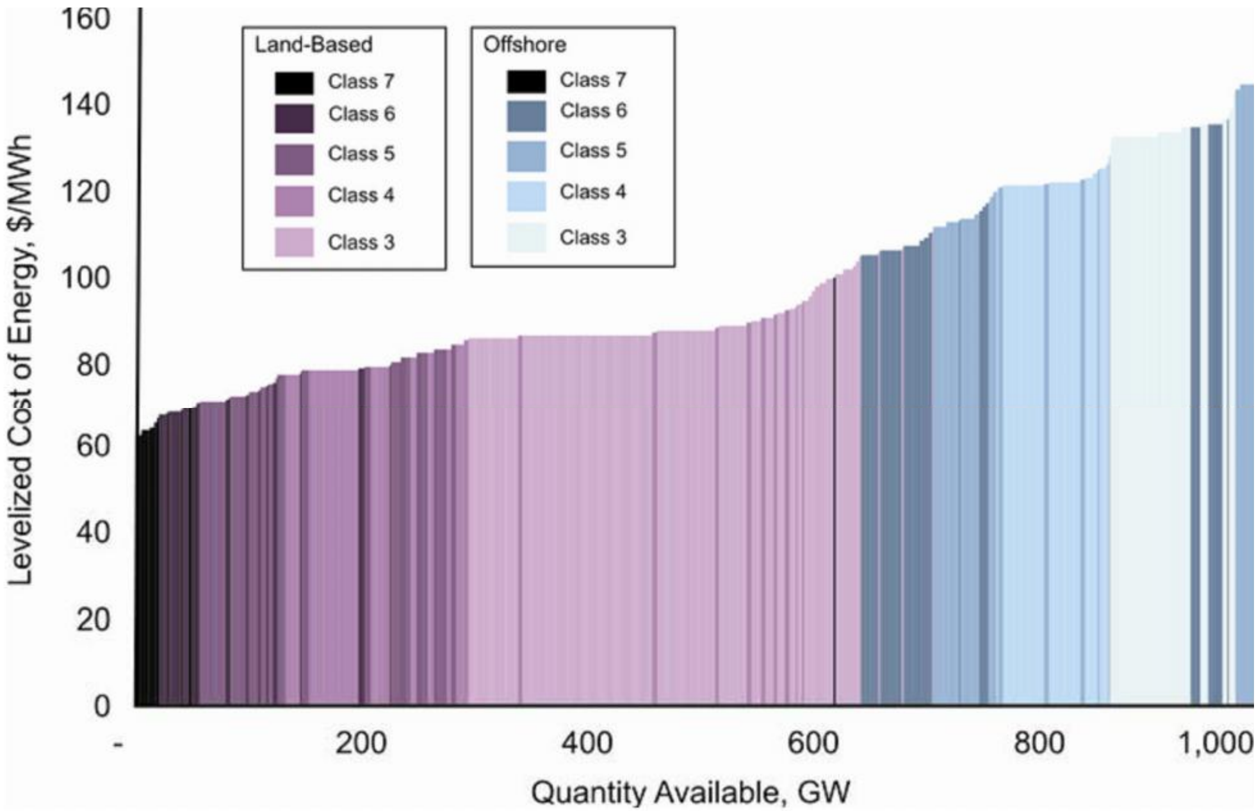
US Wind Resource

Supply curve for wind energy—energy costs including connection to 10% of existing transmission grid capacity



Source: 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply - DOE/GO-102008-2567 • July 2008

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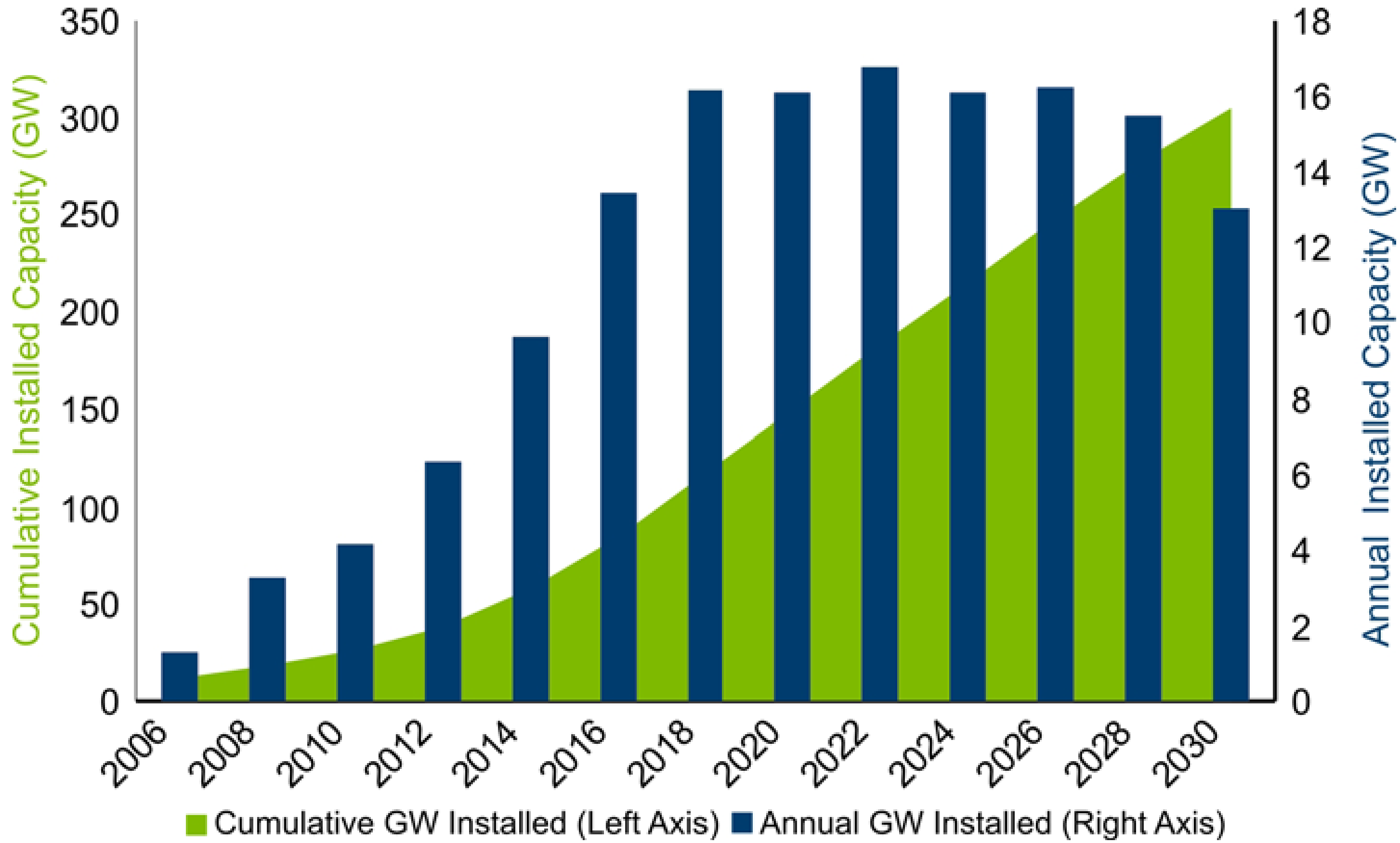
20% Wind by 2030



Source: 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply - DOE/GO-102008-2567 • July 2008

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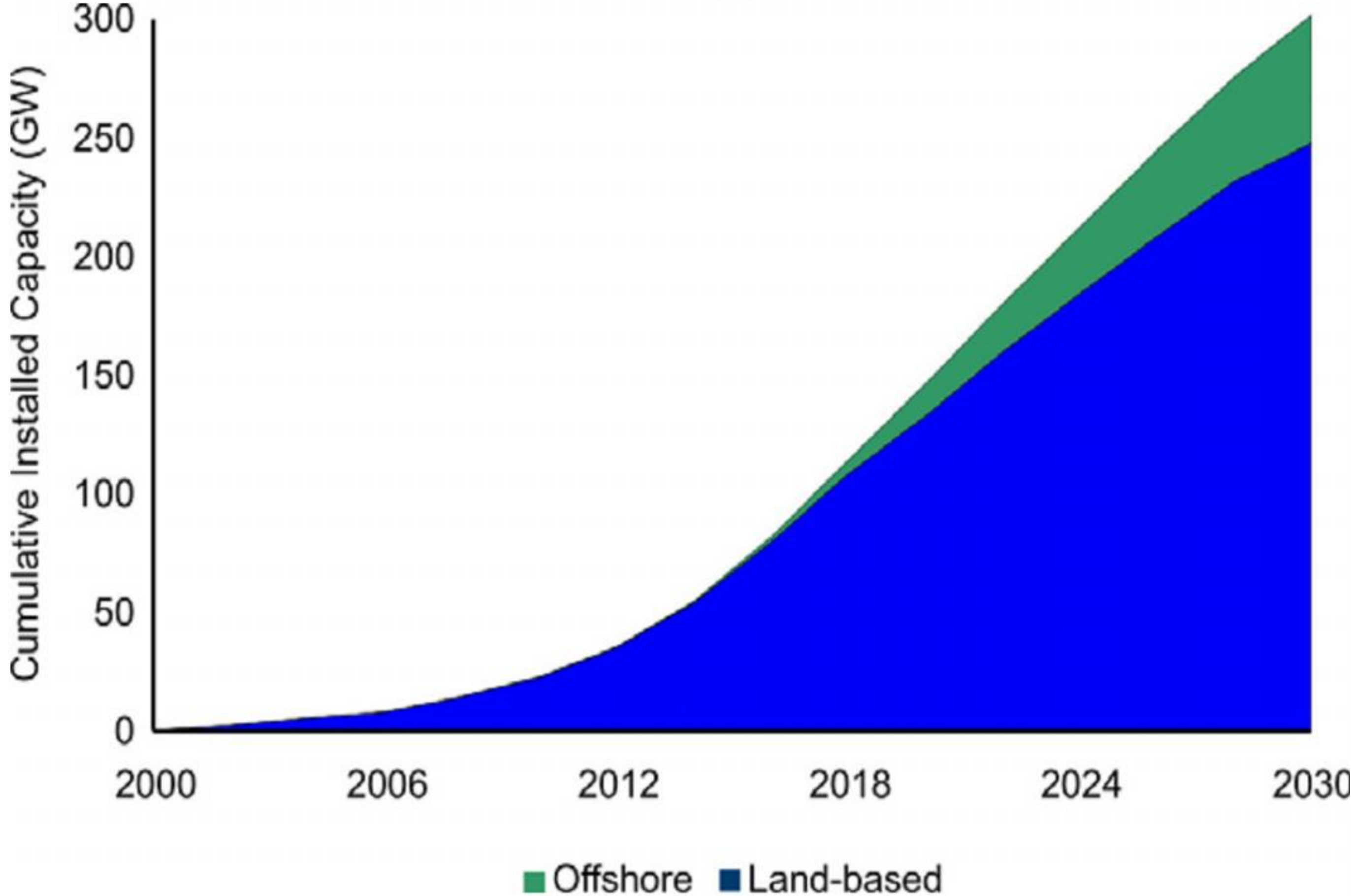
20% Wind Energy Plan 2030



Source: 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply - DOE/GO-102008-2567 • July 2008

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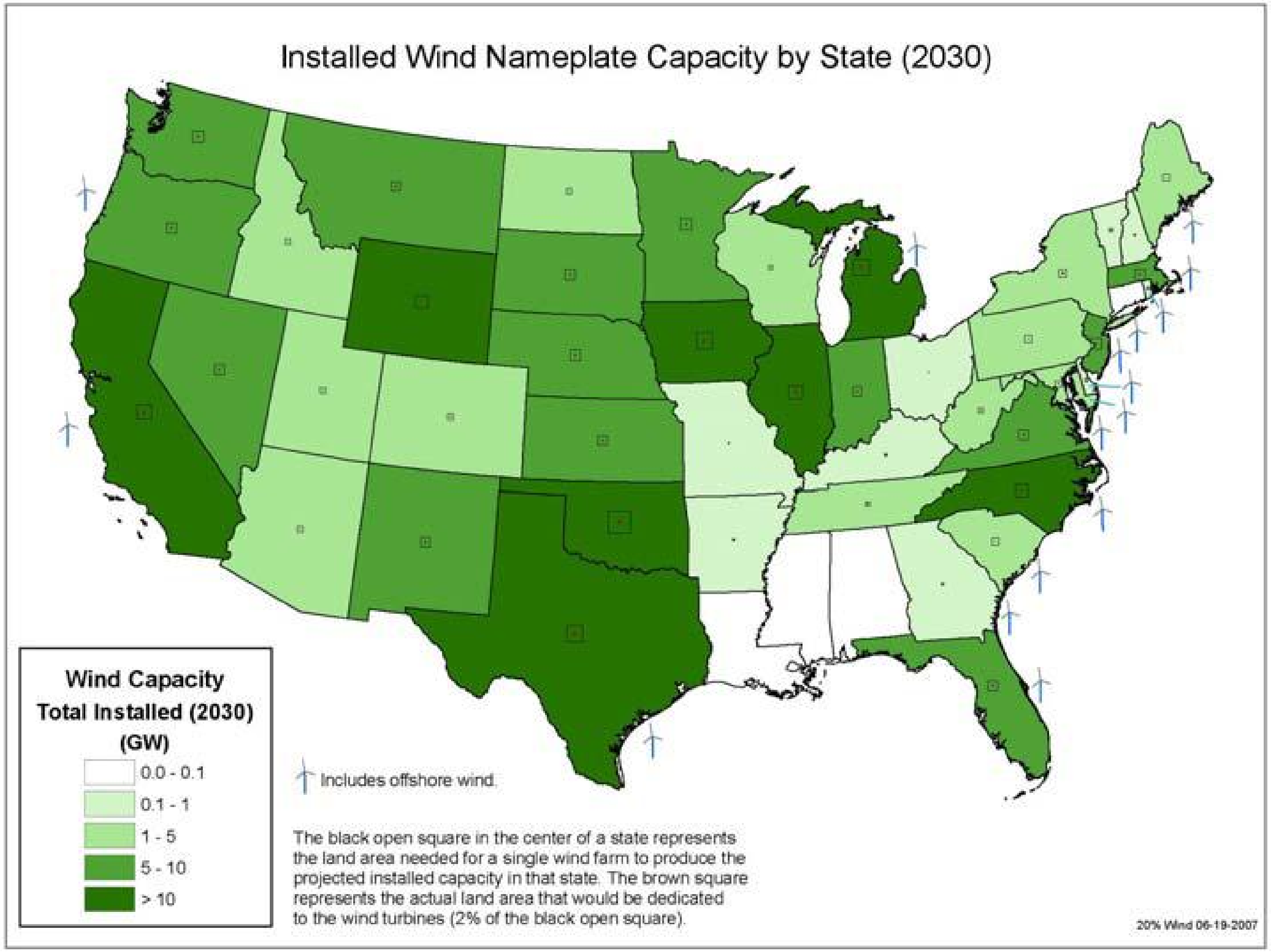
Geography



Source: 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply - DOE/GO-102008-2567 • July 2008

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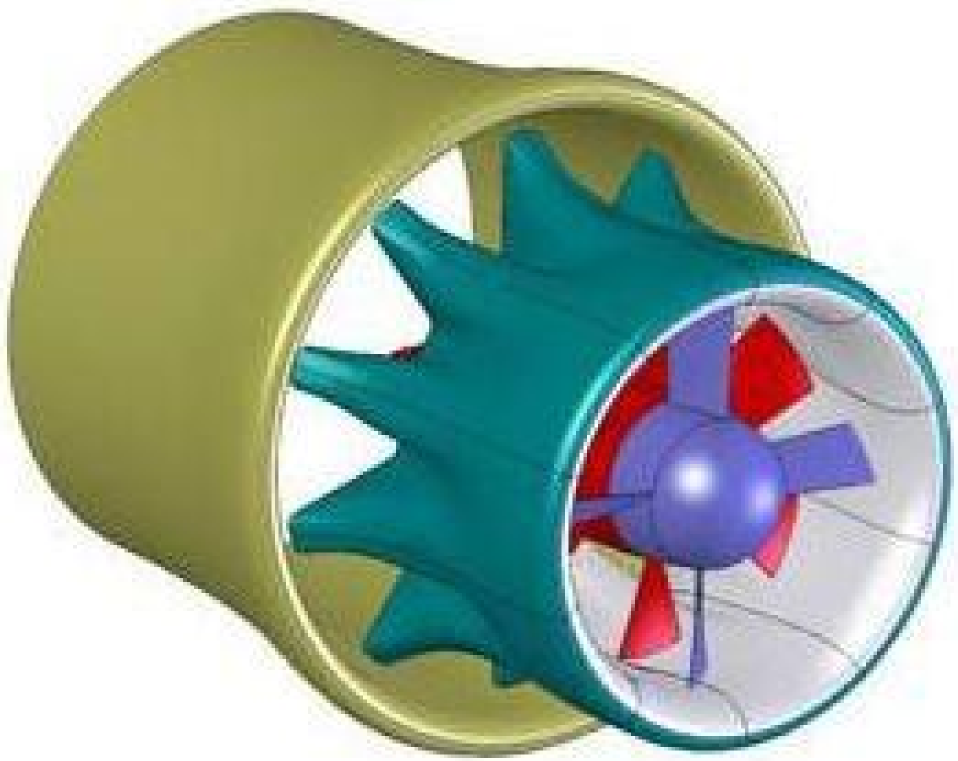
Disruptive Wind Turbine Technology?

FloDesign Wind Turbine



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Compare Target Prices for Energy

Energy Source/Use	Price ($/Qty)	Price (n$/joule)
Coal	$70/tonne	2.33
Petroleum	$40/bbl	6.56
Natural Gas	$7/cu ft	7.00
Wood	$150/cord	8.17
Biodiesel	$1.89/gallon	15.03
Gasoline	$1.89/gallon	15.65
Ethanol	$1.89/gallon	23.67
Electricity	$0.12/kWh	33.33
Multigrain Crackers	$2.99/box	600.00

Note: The Economist June 2008 Special Report on Energy makes the claim that a farmer in Iowa could devote ¼ of an acre to wind and generate $10,000 worth of electricity while devoting the same acreage to corn would yield $300 worth of corn ethanol.

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Biofuels ⇔ Focus of R&D

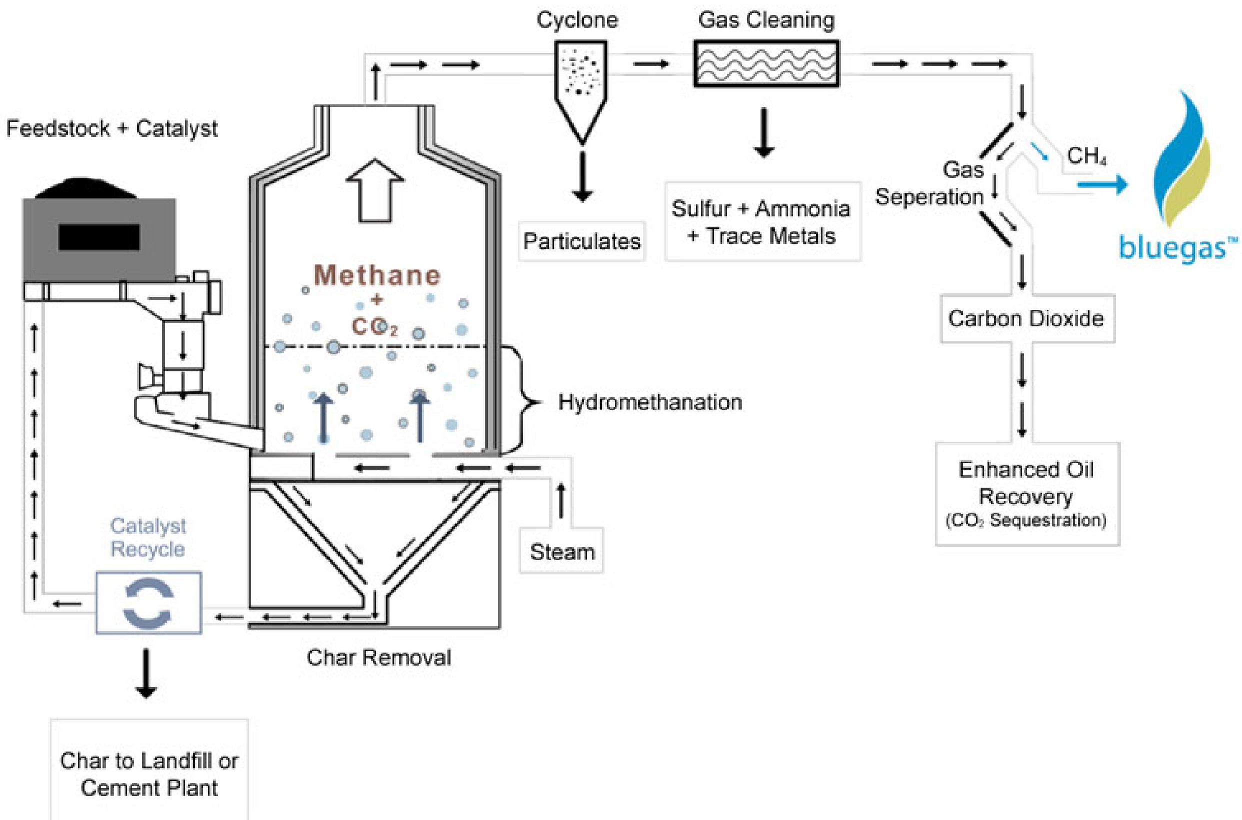
- Feedstock Development
  - Cellulose
  - Switch-grass
  - Sugar Cane
  - Trees
  - Algae
- Fuel Conversion Process
  - Microbes
  - Enzymes
  - Catalysts

Source: The Economist, June 21 2008, The Power and the Glory – A Special Report on Energy

Companies

- Synthetic Genomics
- Choren Industries
- Range Fuels
- Coskata
- Amyris & Crystalev Partnership
- Ceres
- ArborGen
- Mascoma
- Iogen
- Abengoa
- LS9
- Codexis & Shell Partnership
- Danisco & Dupont Partnership
- Virent Energy & Shell Partnership

Hydromethanation Process



Source: www.greatpointenergy.com

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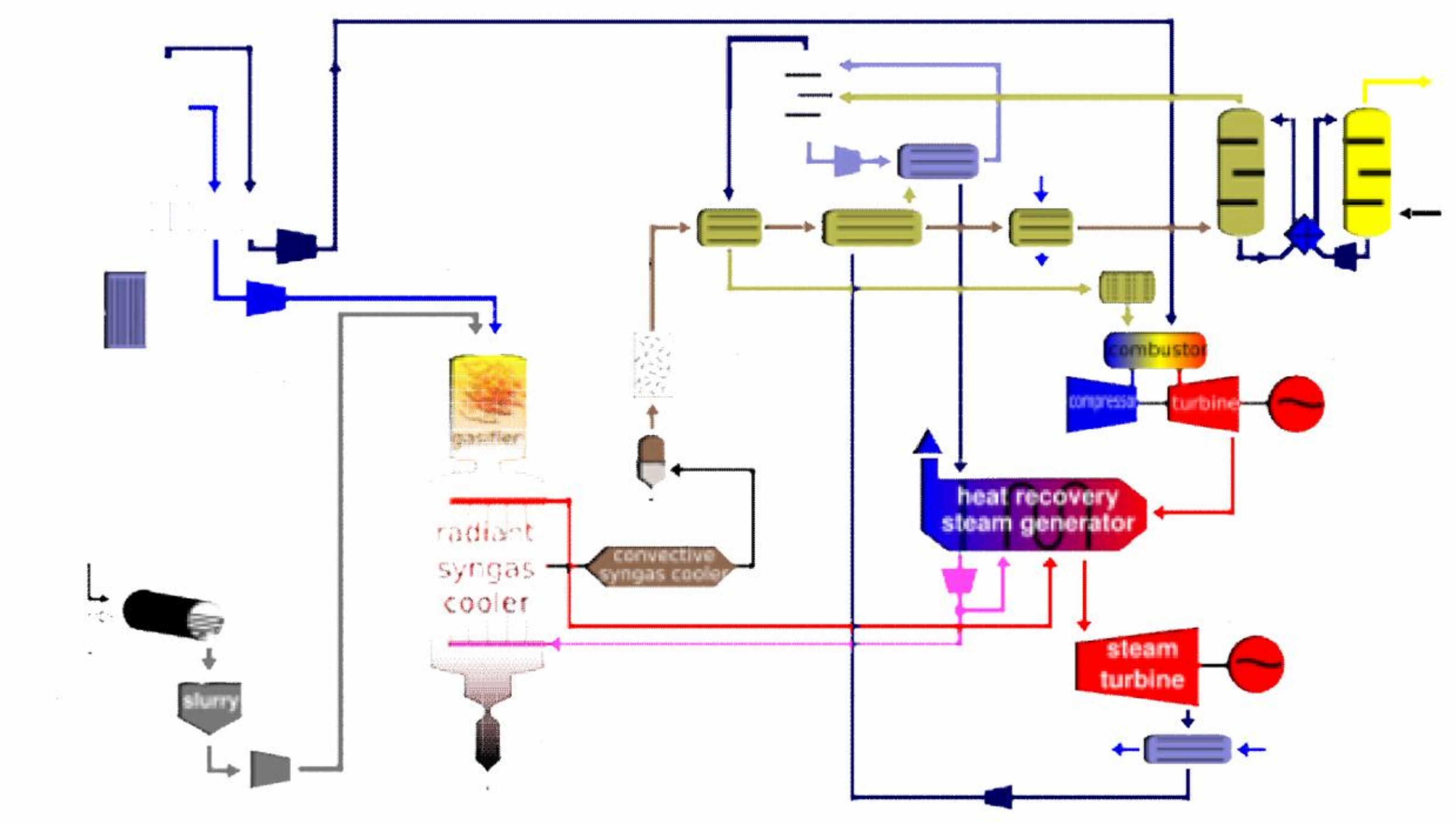
Integrated Gasification Combined Cycle



Source: http://en.wikipedia.org/wiki/Integrated_Gasification_Combined_Cycle

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Electric Vehicles ⇔ The Tesla Roadster

Tesla Economics

- 54 kWh (70 Amps:220 Volts)
- $.046 per mile at $.17 per kWh

Porsche 911 GT3 Comparison

- 20 mpg
- $.10 per mile at $2.00 per gallon

Carbon Emissions

- .98 lbs CO_2 per mile for Porsche
- .28 lbs CO_2 per mile for Tesla
- 72% reduction

Chevy Volt Economics

- Range is 40 miles
- 8 kWh – 110 Volts for 6.5 hours
- $.034 per mile at $.17 per kWh
- $.073/mile - 27.5 mpg & $2/gal
- 70+% reduction in CO_2

Sources:
http://www.teslamotors.com
http://gm-volt.com
http://www.eia.doe.gov

0 – 60 mph in 3.9 seconds
14,000 rpm redline
200+ mile range
3.5 hour recharge time
Roadster Sport introduced 1-11-2009

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Active VC Firms

- Advanced Technology Ventures
- ARCH Venture Partners
- Atlas Venture, Ltd.
- Draper Fisher Jurvetson
- Flagship Ventures
- General Catalyst Partners
- Globespan Capital Partners
- Good Energies, Inc
- Khosla Ventures
- Kleiner Perkins Caulfield & Byers
- Mohr Davidow Ventures
- Nth Power
- Oak Investment Partners
- Polaris Venture Partners
- Rockport Capital Partners
- Trident Capital
- VantagePoint Venture Partners
- Venrock Associates
- @Ventures

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Venture Capital in this Sector ⇔ Rob Day @Ventures

- More than 100 VC firms
- Mega-funds of more than $300 million
- Investments crowded at late stage
- Investments crowded into solar, transportation and bio-fuels
- Crowded into California and New England where the VC firms are located
- Development times are longer in Clean Tech
- Counting on IPO when M&A is more probable
- Need to apply VC model that works rather than search for a VC model that works for Clean Tech

Source: Rob Day as found at http://www.ventures.com/

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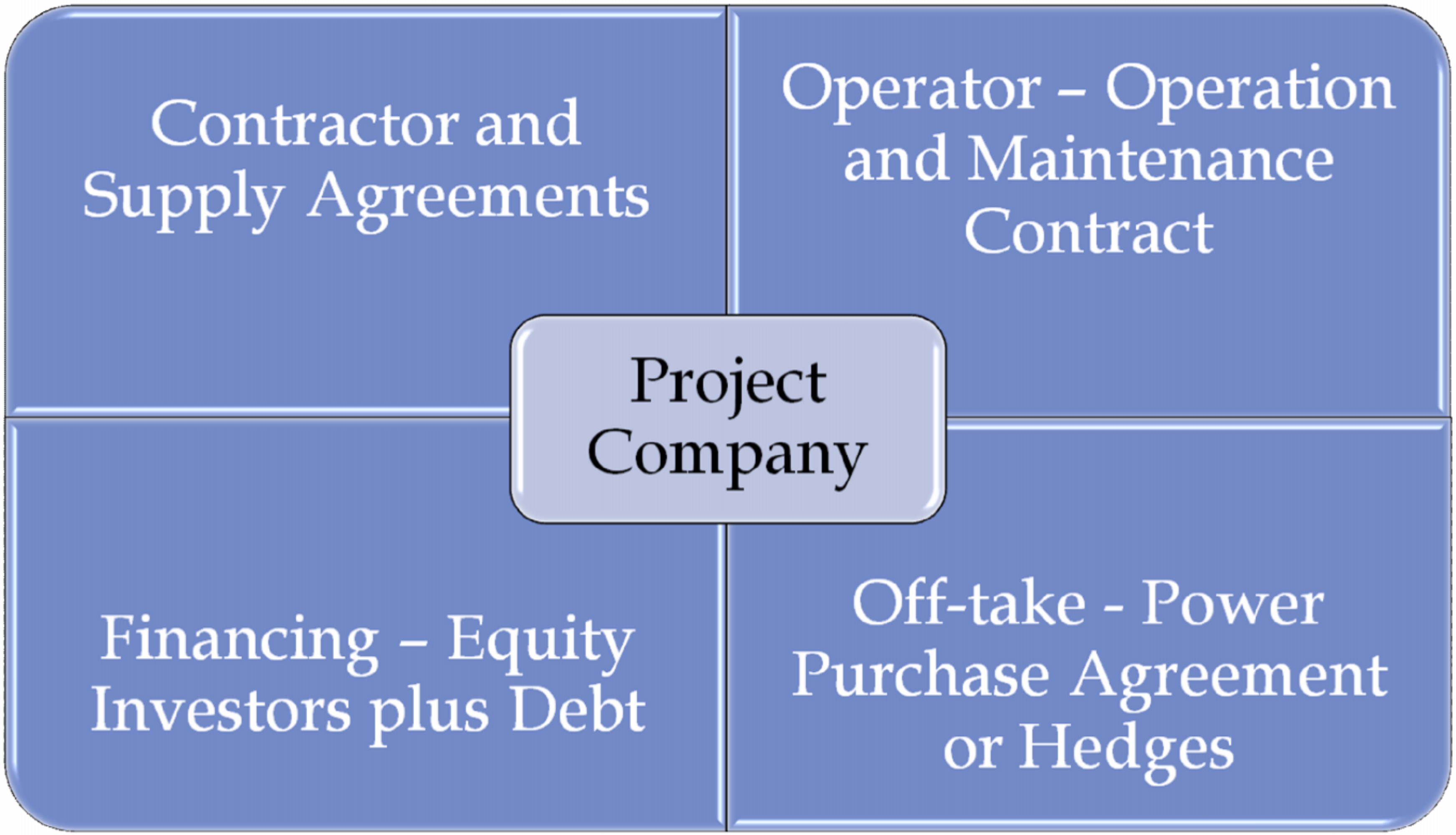
Project Structure



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Wind Project Financing Structures

Financing Structure Name	Project Capital Structure	Likely Equity Investors	Description of Equity Investor	Levelized Cost of Electricity ($/MWh)
Corporate	All equity	Developer	Corporate Entity – FPL	63
Strategic Investor Flip	All equity	Developer and Strategic Investor	Utility – Xcel Energy	61
Institutional Investor Flip	All equity	Developer and Institutional Investor	Financial Institution – Lehman Bros.	53
Pay-As-You-Go ("PAYGO")	All equity	Developer and Institutional Investor	Same as above	59
Cash Leveraged	Equity & debt	Developer and Institutional Investor	Same as Above	50
Cash & PTC Leveraged	Equity & debt	Developer and Institutional Investor	Same as Above	48

Source: Lawrence Berkeley National Laboratory - http://eetd.lbl.gov/ea/ems/reports/63434.pdf

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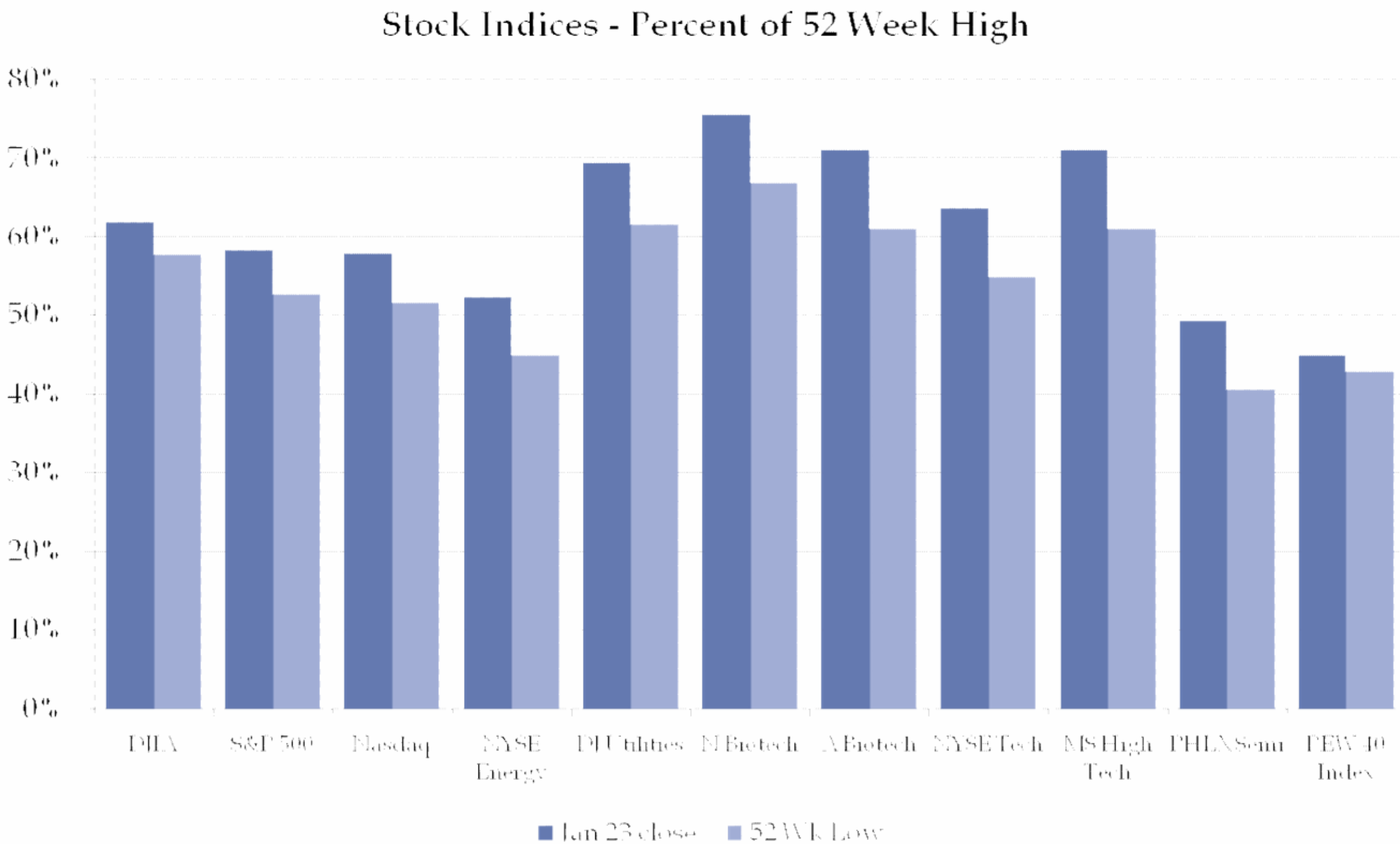
Opportunities for FENG Member?



Source: For REW 40 Index go to www.renewableenergyworld.com and then click on Finance

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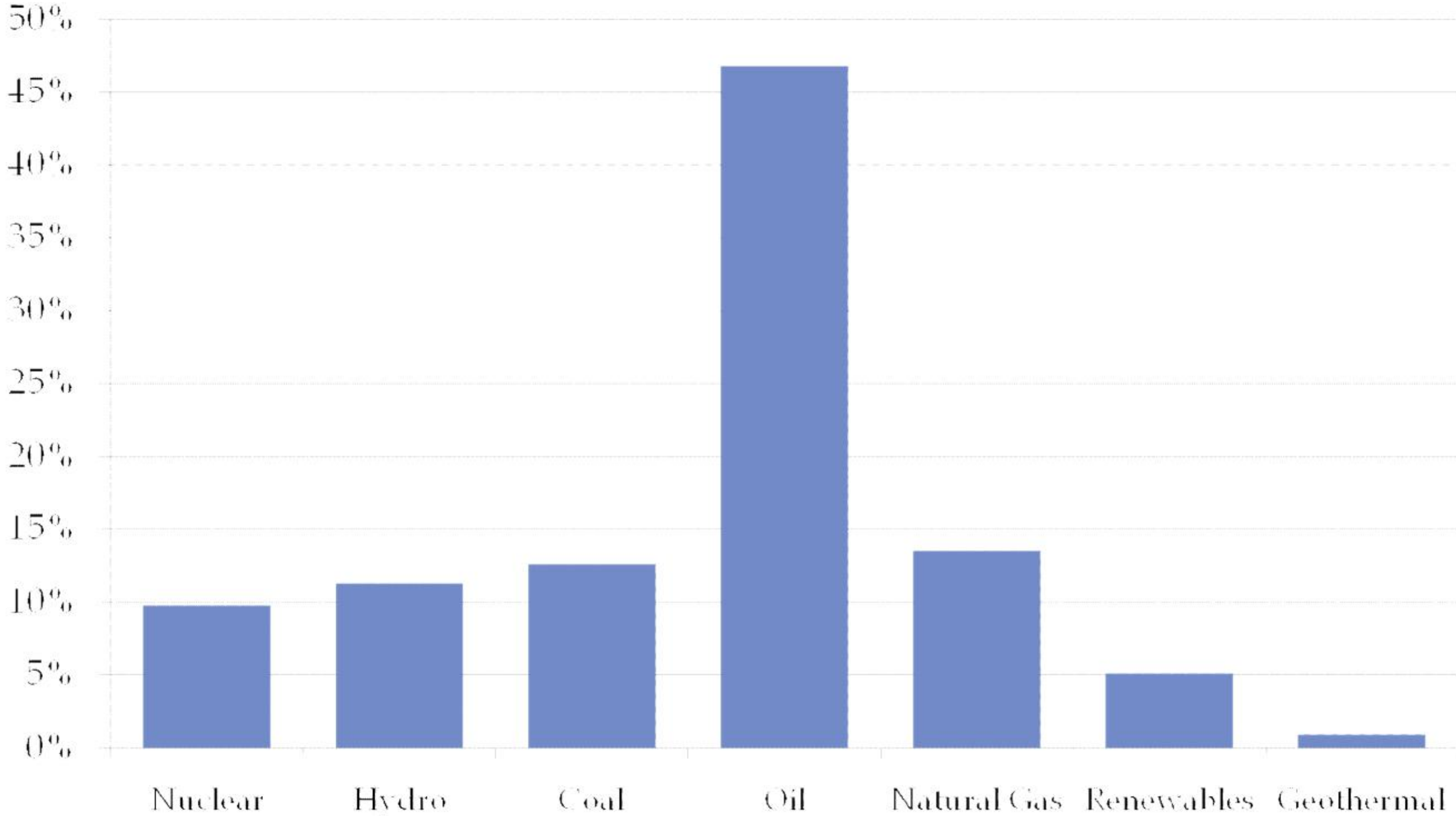
Federal Energy Incentives by Source (1950-2003)



Source: Management Information Services, Inc. (2006)

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Policies of the New Administration

- Five million new clean energy jobs
- Invest $150 billion over the next ten years
- Supports PTC and ITC
- 1 million Plug-In Hybrid cars by 2015
- 25 percent renewable electricity by 2025
- Renewable Fuels Standard – 36 billion gallons
- Implement cap-and-trade program
- Reduce GHG emissions 80 percent by 2050
- Go to: http://www.whitehouse.gov/agenda/energy_and_environment/