

Energy  
in an  
Integrated Program of Research  
on  
Water, Energy and Environment

Questions and Suggestions for LUMS

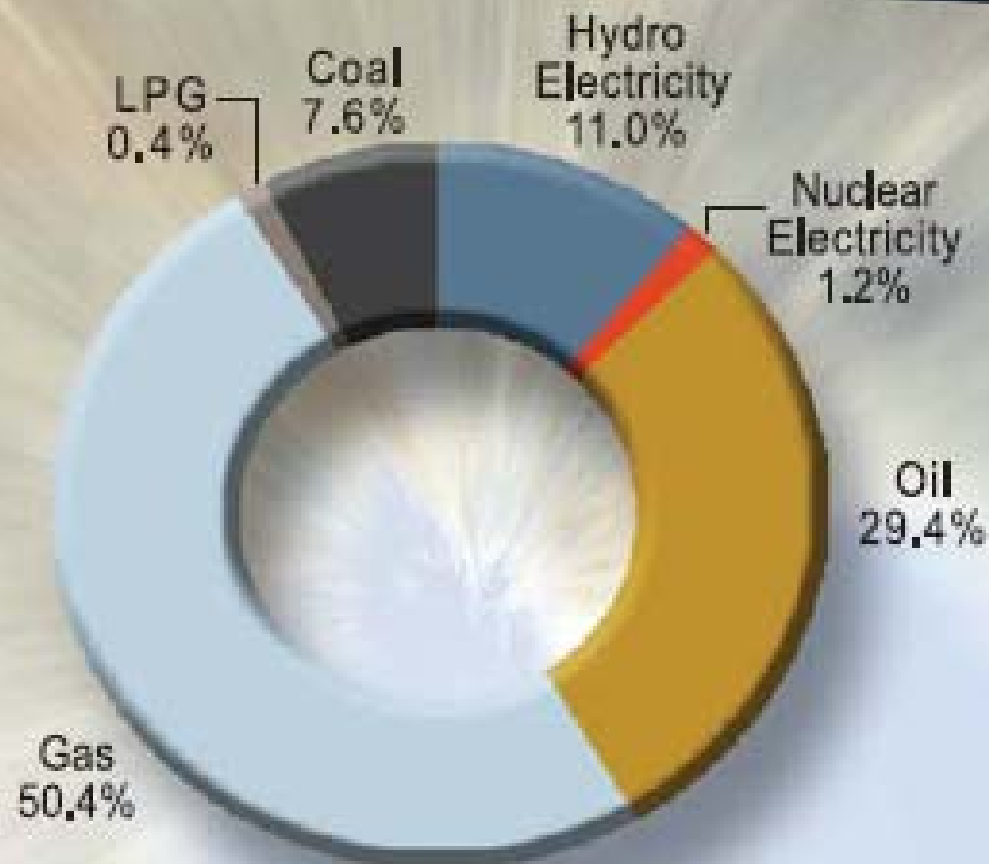
by

Khalid Aziz  
Stanford University

# Pakistan's Primary Energy Supplies

by Source (2004-2005)

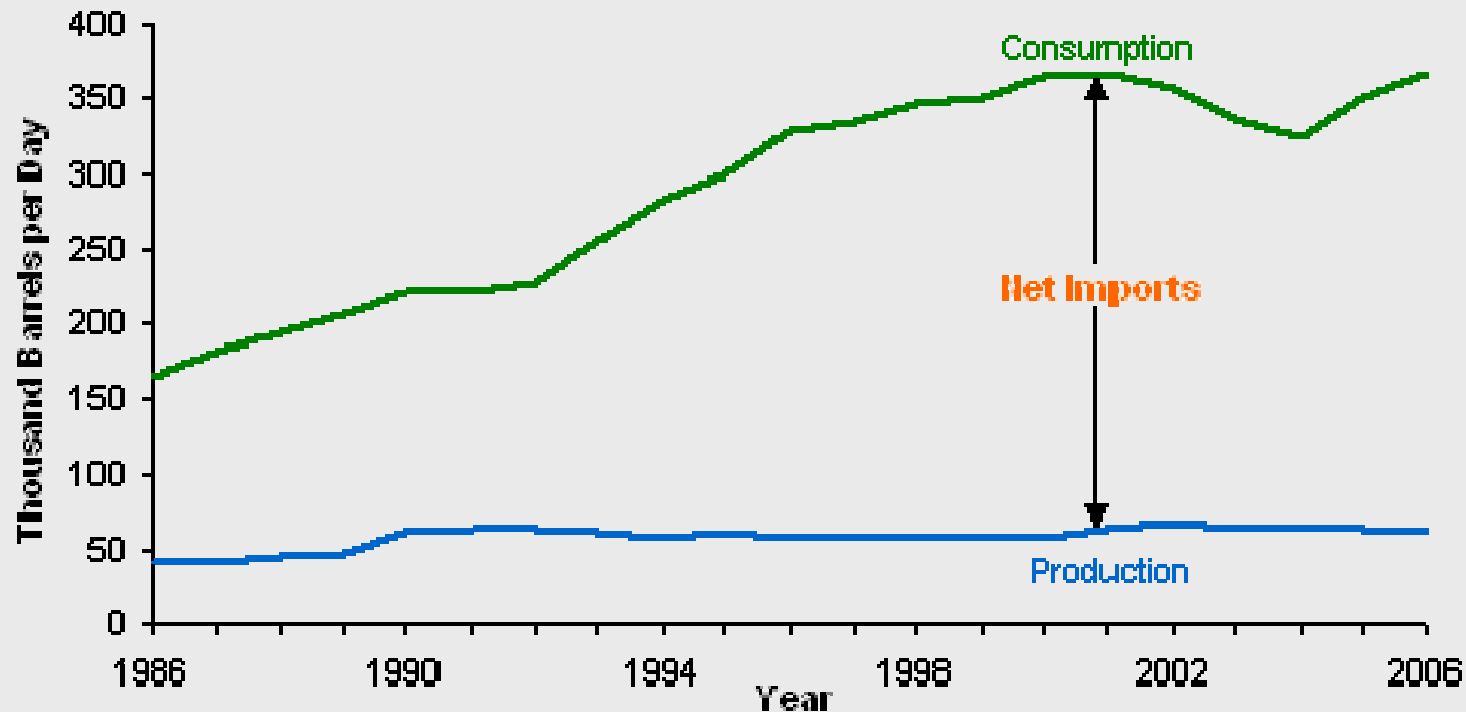
From: PPL  
Progress,  
August 05



Source: HDPI

# Can Pakistan continue importing larger and larger quantities of oil?

Pakistan's Oil Production and Consumption, 1986-2006<sup>1</sup>



Source: EIA *International Energy Annual 2004*;  
*Short Term Energy Outlook November 2006*

\*2006 is forecast

This year Pakistan will import oil worth \$7.5 billion  
Last 12 months trade balance deficit: \$12.1 billion  
Foreign Reserves: \$11 billion (Economist)

# Water, Energy and Environment

- Most do not have access to clean drinking water
- Direct losses from environmental damage: \$1.8 billion per year.
- The level of air pollution in Karachi and Lahore 20 times higher than WHO standards
- Pakistani vehicle emits 20-25 times more pollutants than the average U.S. vehicle
- Pakistan's energy consumption tripled in 20 years, from 0.6 quadrillion Btu in 1980 to 1.9 quads in 2001. Still, Pakistan accounts for less than 0.5% of total world energy consumption  
Most

<http://www.eia.doe.gov/emeu/cabs/pakenv.html>

# Policy on Renewable Energy 2006

Federal Minister for Water and Power, Liaquat Ali Jatoi (December 18, 2006)

- Small renewable projects
  - No permission from the government
  - Can sell surplus power to distribution companies
- Alternate Energy Development Board (AEDB) to deal with the wind and solar projects
- No custom duty or sales tax on equipment
- Exemption allowed from income tax

Curtsey: Salal Humair

# Pakistan's Energy Options

- Expand exploration for fossil fuels through appropriate incentives
- Make existing systems more efficient
- Invest in renewables and develop technologies suitable for the region
  - Solar?
  - Wind?
  - Biofuels?
  - Nuclear?

# Global Power Demand and Clean Renewable Supply

	TW
Global overall power demand	9.4-13.6
Potential renewable availability	
Solar over land	1700
Land-wind at 80 m and $> 6.9$ m/s	72 <sup>a</sup> , 80 <sup>b</sup>
Geothermal	9.5 <sup>b</sup>
Hydroelectric	6.5 <sup>b</sup>
Wave	5 <sup>b</sup>
Tidal	3.7 <sup>b</sup>

<sup>a</sup>Archer and Jacobson, 2005; <sup>b</sup>Stacey and Davis, 2006

# Installed Wind Capacity Worldwide

Country	Installed (MW)
Germany	18,428
Spain	10,027
U.S.	9,149
India	4,430
Denmark	3,122
World	59,084 at end of 2005

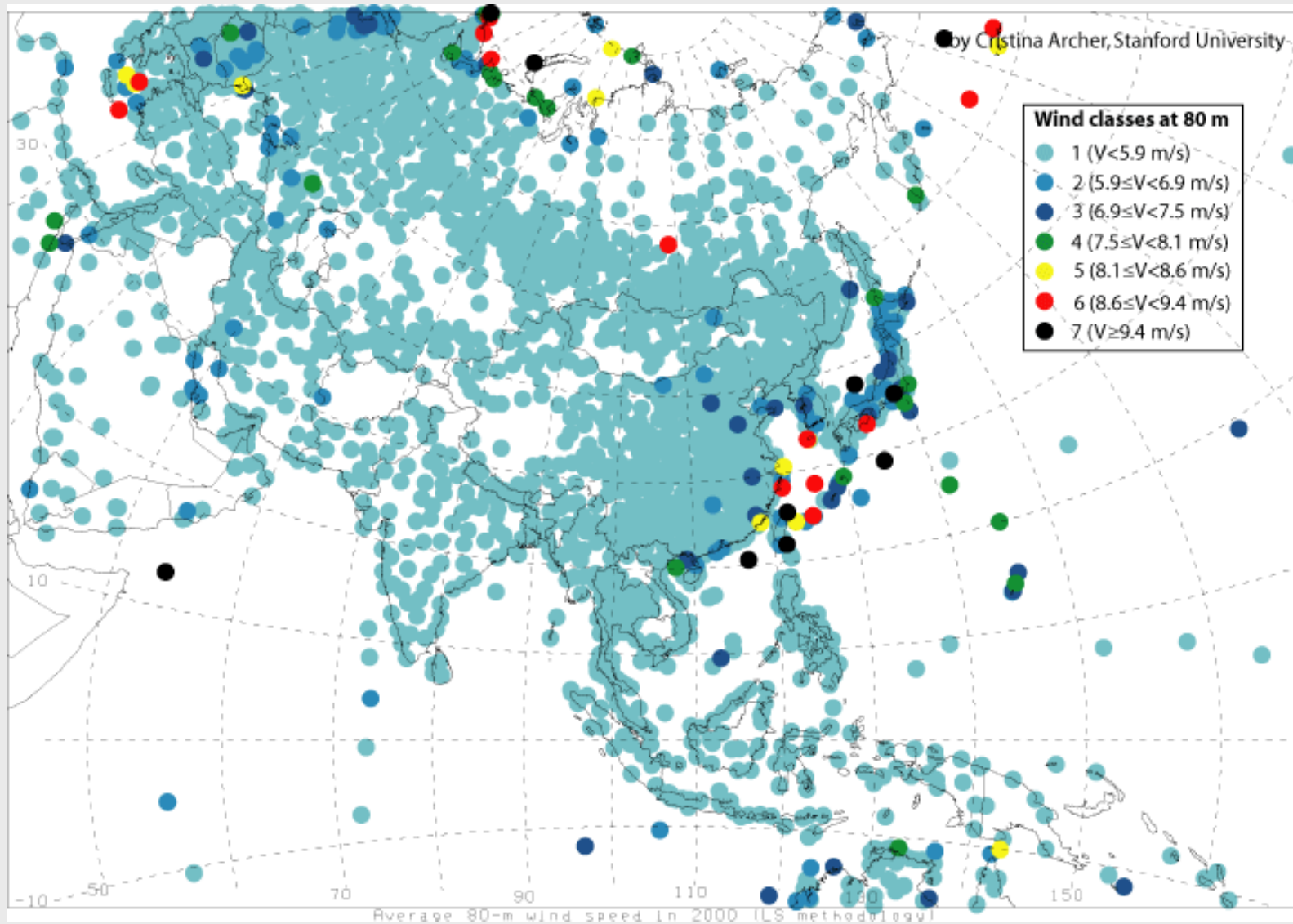
# Emerging Energy Research

<http://www.renewableenergyaccess.com>

December 14, 2006

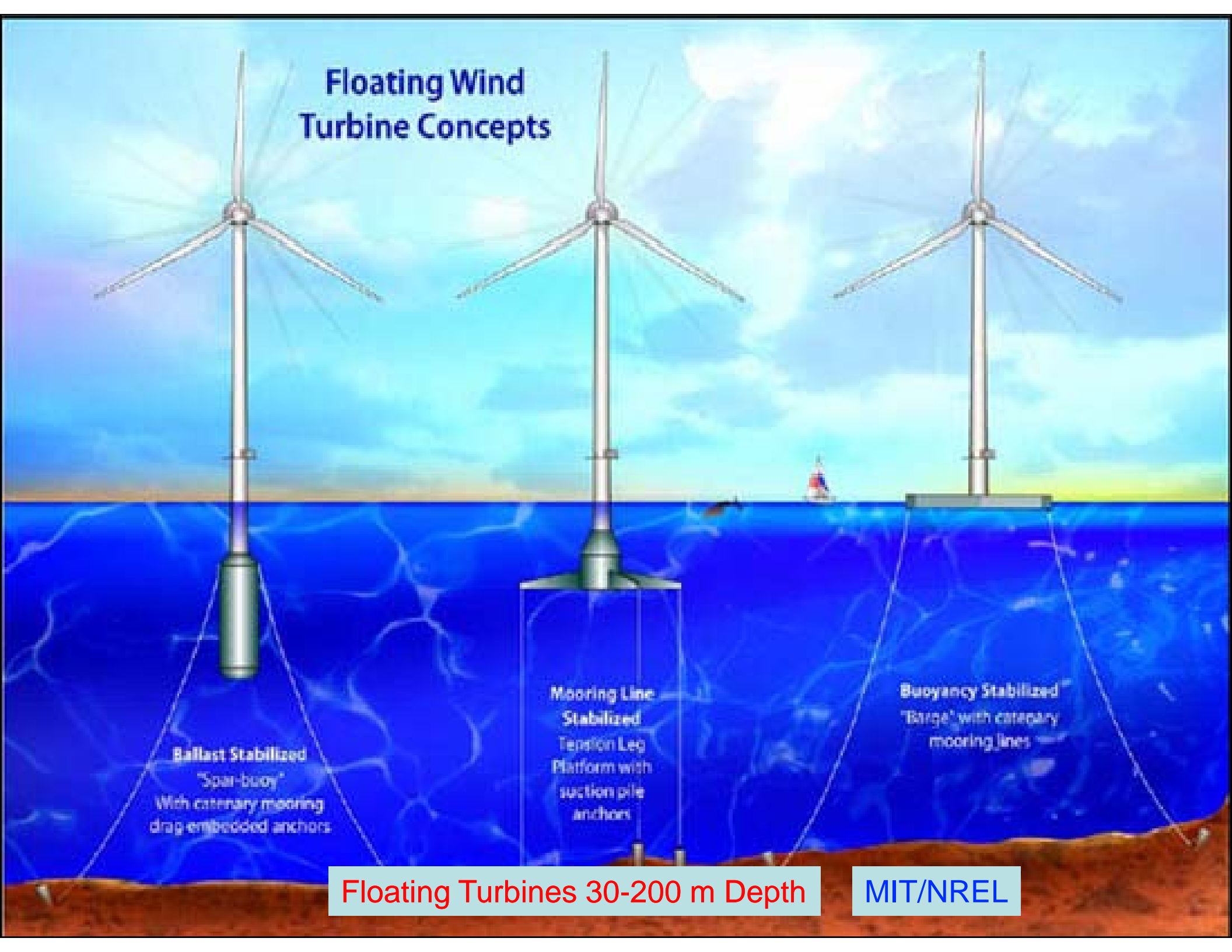
- China and India are expected to lead the region by adding over 36,000 MW between them by 2015.
- Japan and Australia will each add between 100 and 300 MW per year followed by less-developed markets in South Korea, New Zealand, Taiwan, Pakistan and the Philippines.

# Estimated Wind Speed at 80 m 77-m Diameter, 1500 kW Turbines.



Archer and Jacobson, 2005

# Floating Wind Turbine Concepts



**Ballast Stabilized  
"Spar-buoy"**  
With catenary mooring  
drag-embedded anchors

**Mooring Line  
Stabilized  
Tension Leg  
Platform with  
suction pile  
anchors**

**Buoyancy Stabilized  
"Barge" with catenary  
mooring lines**

Floating Turbines 30-200 m Depth

MIT/NREL

## HYDROSOL-II

# Solar Hydrogen via Water Splitting in Advanced Monolithic Reactors for Future Solar Power Plants

(020030 SE S6)

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Courtesy: Bilal Zuberi

[https://www.hfpeurope.org/uploads/1105/1611/HYDROSOL-II\\_KONSTANDOPOULOS\\_TechDays05\\_051205\\_FINAL.pdf](https://www.hfpeurope.org/uploads/1105/1611/HYDROSOL-II_KONSTANDOPOULOS_TechDays05_051205_FINAL.pdf)

# General Questions

- How efficient is the current energy production, distribution and use?
- Can this mix be sustained?
- What are the environmental consequences of current practices?
- What can be done in the short and long term to make Pakistan's use of energy affordable, sustainable and environmentally friendly?
- What is the impact of current practices on climate change?
- What should be the mix of distributed versus centralized power generation?

# Possible Areas for Research

- Advanced coal utilization
- Home solar power systems
- Hydrogen production using solar energy
- Hydrogen distribution and use
- Reduction of pollutants from transportation systems
- Reduction, capture and sequestration of CO<sub>2</sub>
- Development of sustainable policies

## A viable research program will depend on...

- People who can recognize problems and have the ability to seek innovative solutions
- Institutional commitment
- Motivation
- Funding
- Possibilities of commercialization of IP

# Susan Hockfield, President of MIT

December 20, 2006

"To fully realize its potential, though, the university community must lower some internal barriers. The standard academic research model of a single investigator, or a small group of people, working on narrowly defined problems is important but, frankly, not sufficient in an energy context. We must develop organizational structures and incentives that encourage large multidisciplinary teams and, where relevant, permit true working partnerships with industry and government groups."

# Dawn

December 20, 2006

- Pakistan is facing a severe energy crisis and its oil consumption has gone up by about 80% over one year
- This alone is expected to increase Pakistan's oil import bill to \$7.5 billion against budgeted projection of \$6.5 billion
- Pakistan's total energy requirement would increase by about 48% to 80 million tons of oil equivalent (MTOE) in 2010 from about 54 MTOE currently