Renewable Energy: Poised to Realize Long-Term Potential

Presented at the
International Association for Energy Economics Conference
Potsdam, Germany

June 10, 2006

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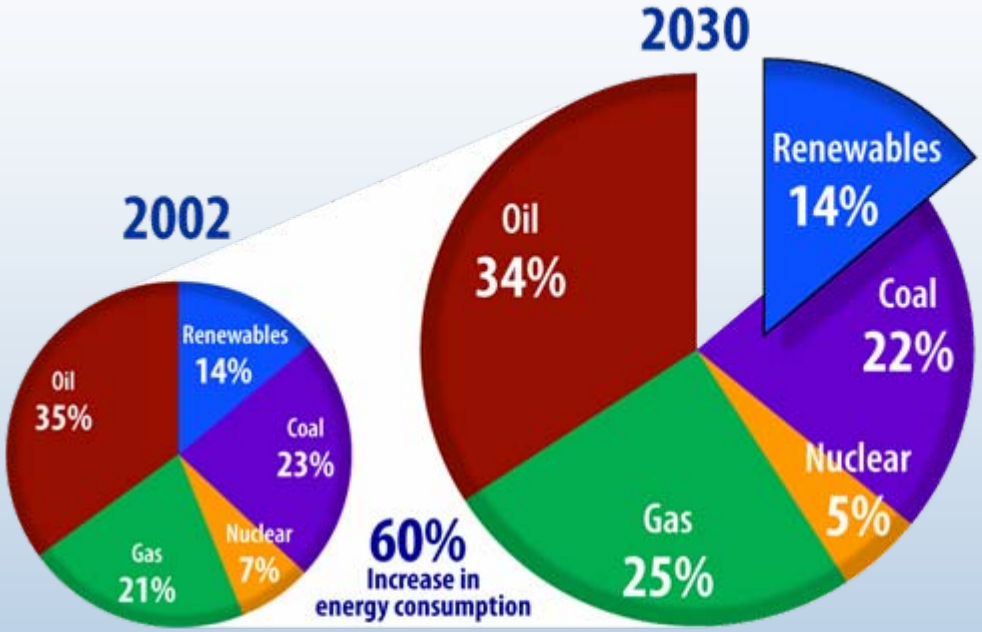
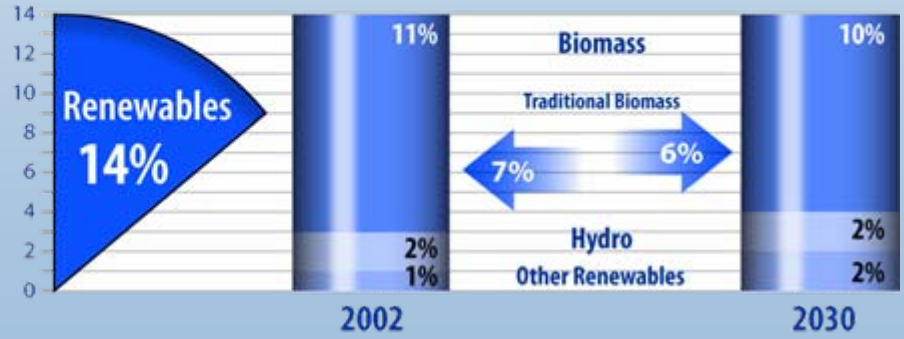
NREL/PR-100-40768

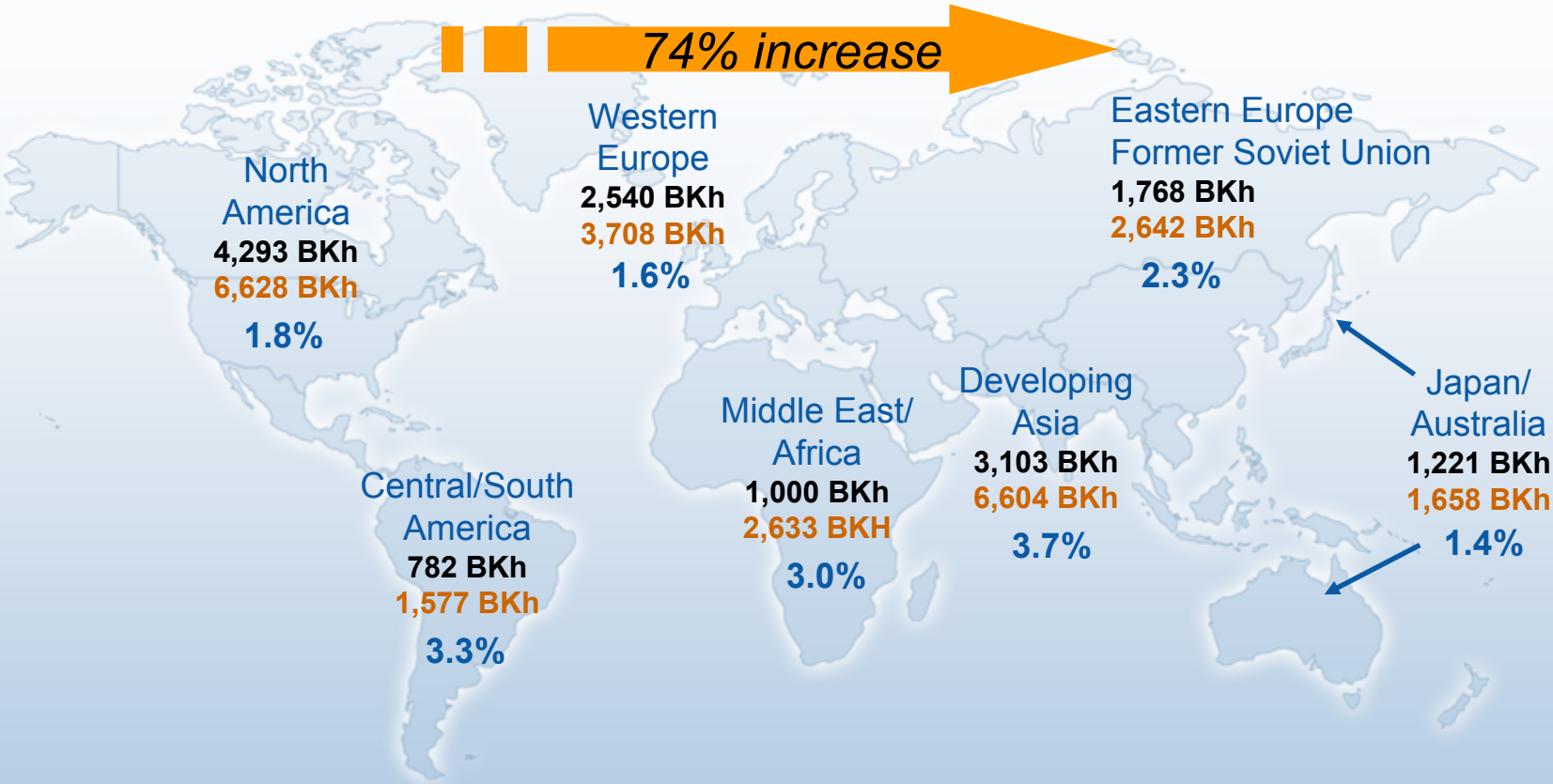
World Energy Supply and the Role of Renewable Energy



Source: OECD/IEA, 2004



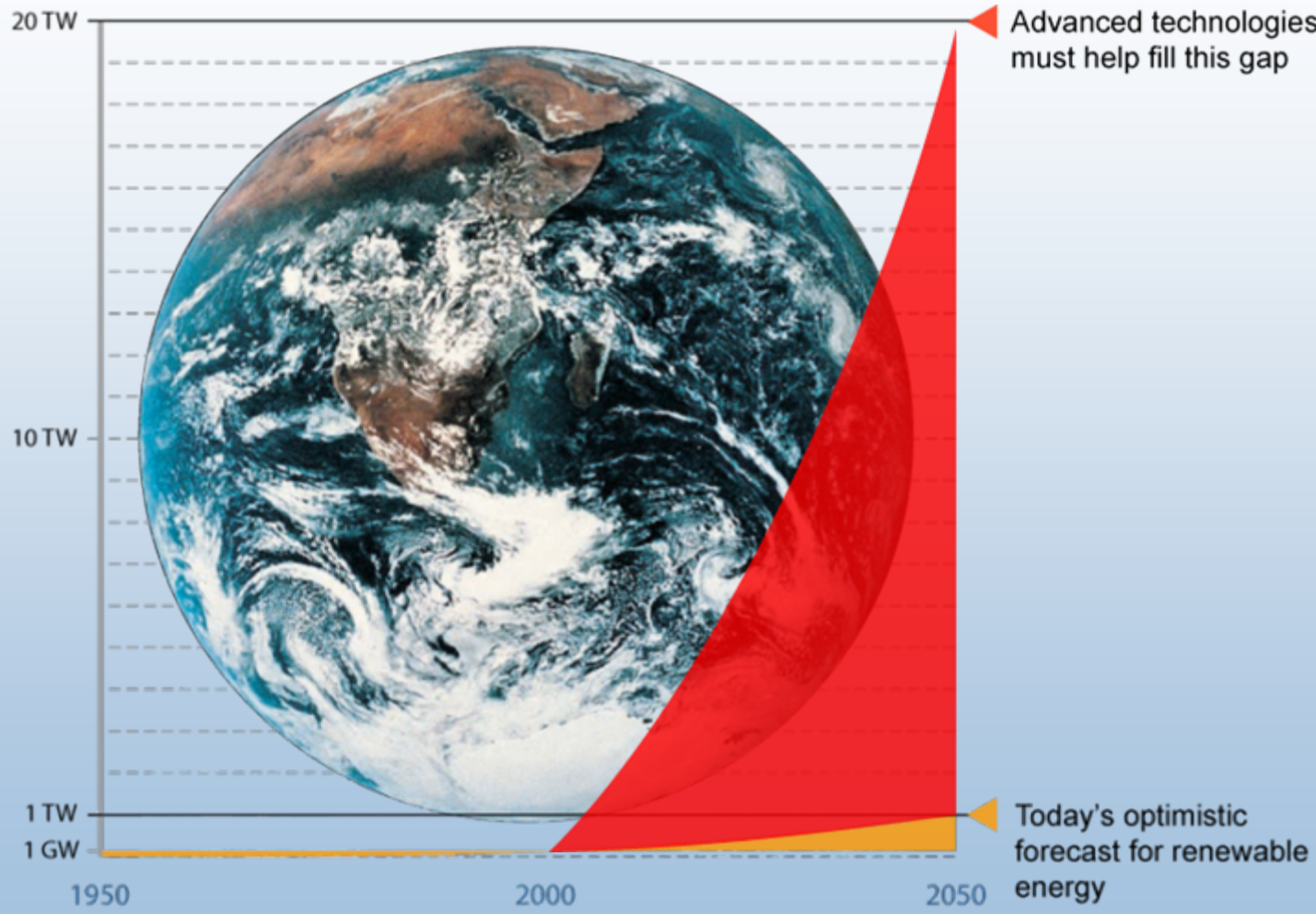
Electricity Outlook: 2001-2025



- Total annual average world electricity growth - 2.4% from 2001 to 2025
- Growth rates in transitioning economies higher than developed economies
- Natural gas and coal will be near-term fuels of choice for generation
- Distributed generation and renewable energy will offer attractive options

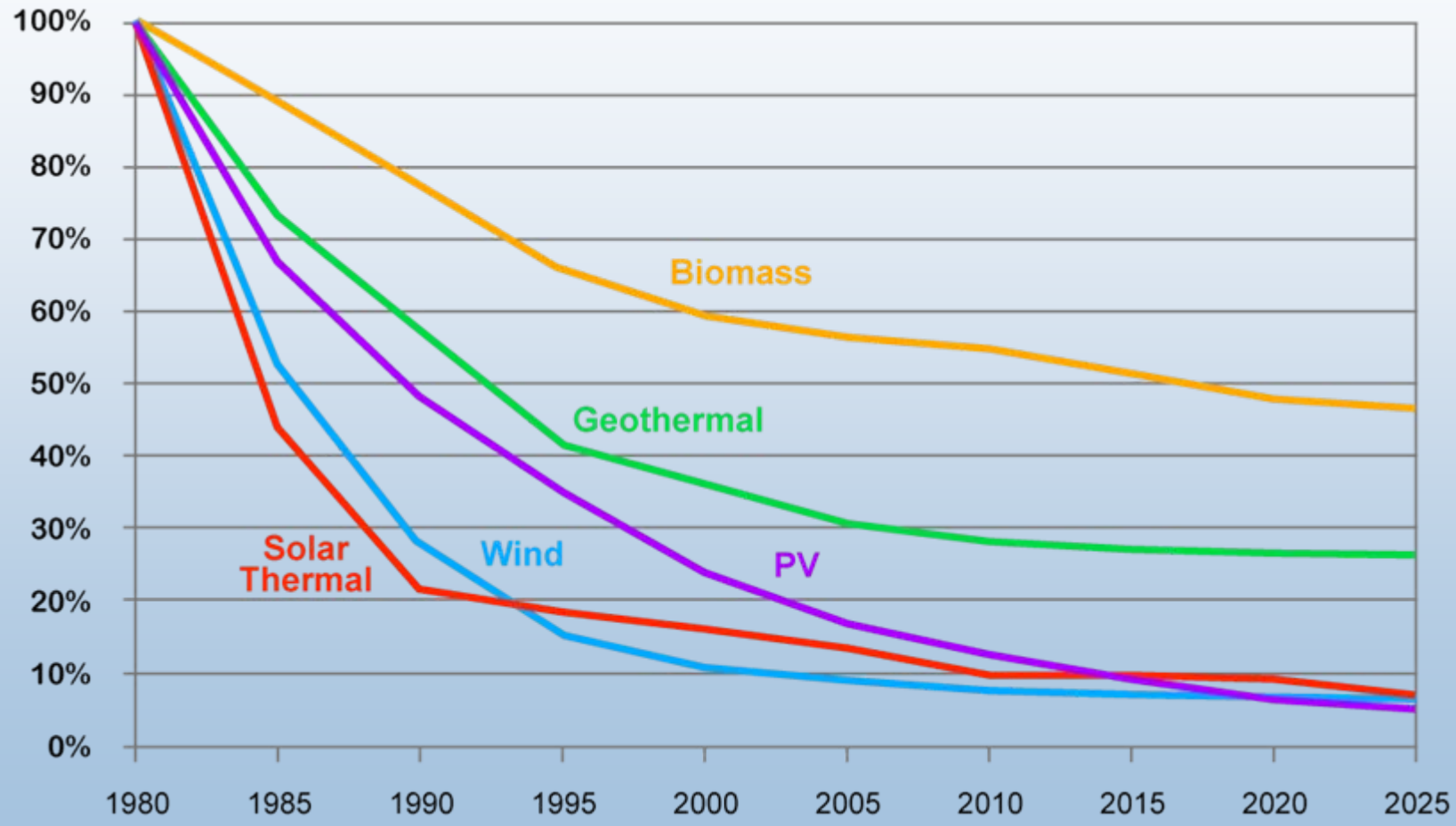
Source: International Energy Outlook 2003, Table A9

Magnitude of Challenge Requires Global Action and a Change in Trajectory



Renewable Energy Electricity Generation Costs as Percentage of 1980 Levels:

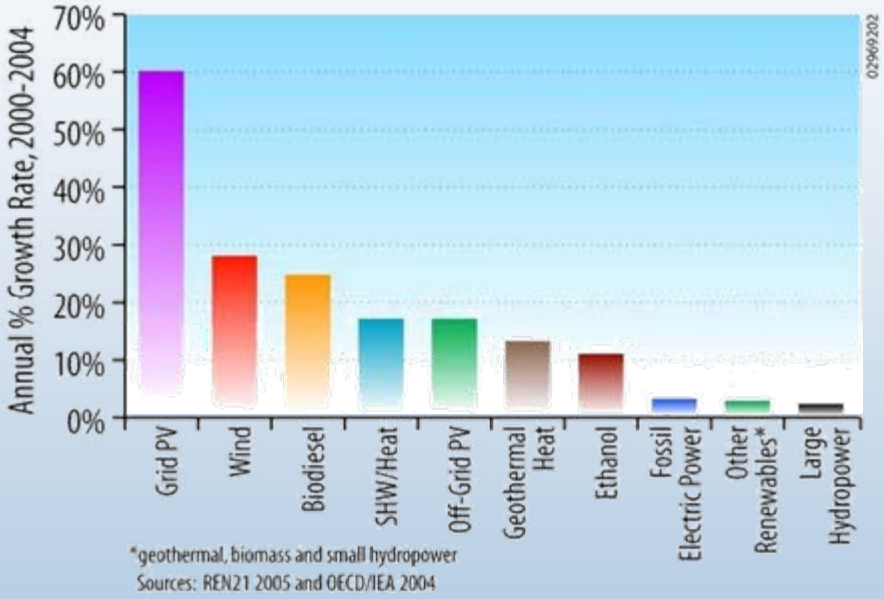
Historical and Projected



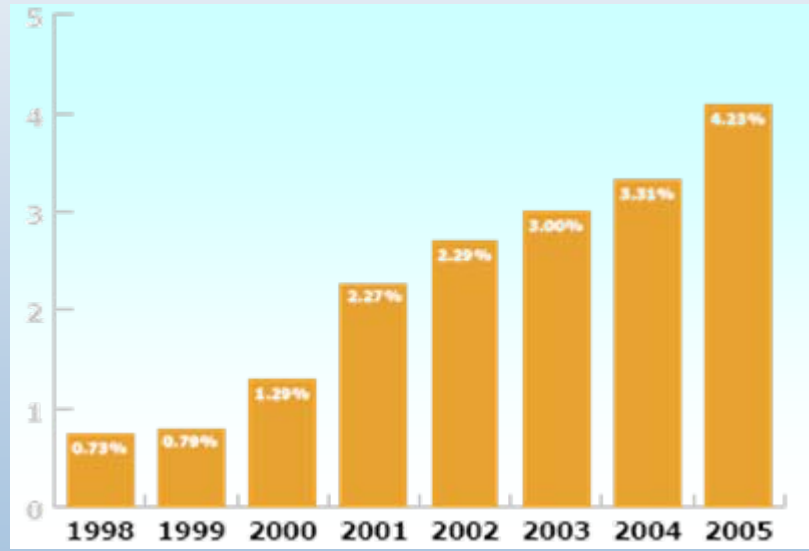
Source: NREL 2005, 2002

Renewable Energy is Growing

Renewable Energy Annual Growth Rates



Energy-Tech Investments as a Percent of Total U.S. Venture Capital



Source: Nth Power LLC

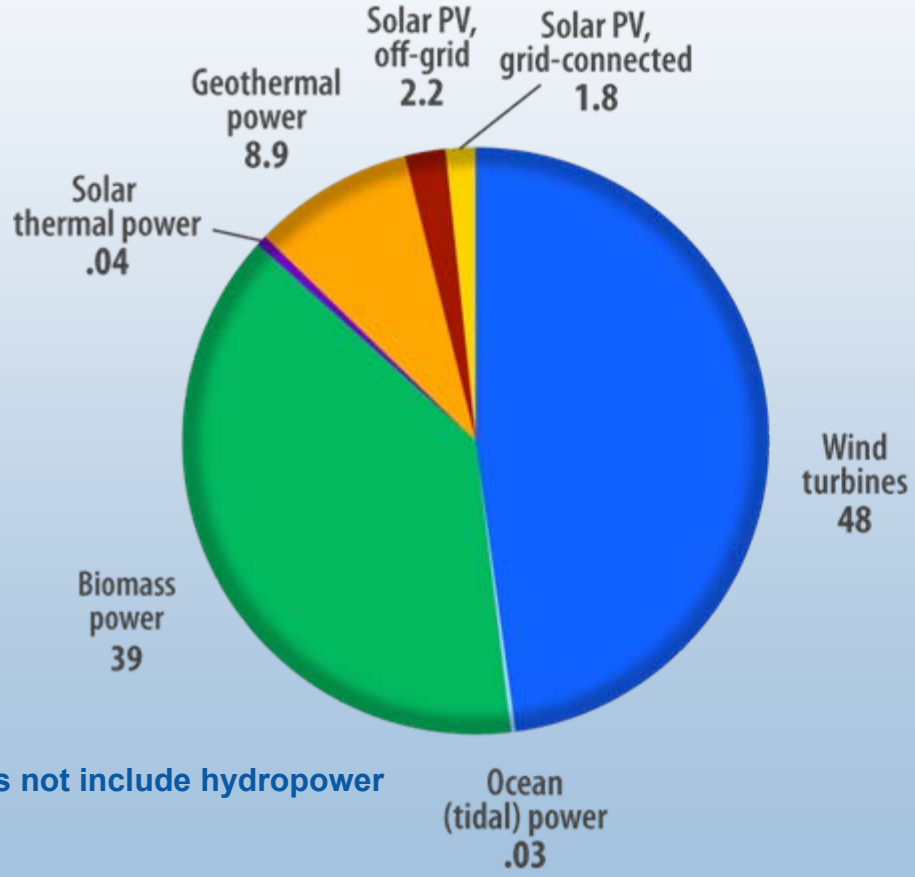
Wind & Solar are each $10B+ industries and there is over a $1B clean energy venture capital market

Renewable Energy Indicators

As of Year End 2004

Power Generation

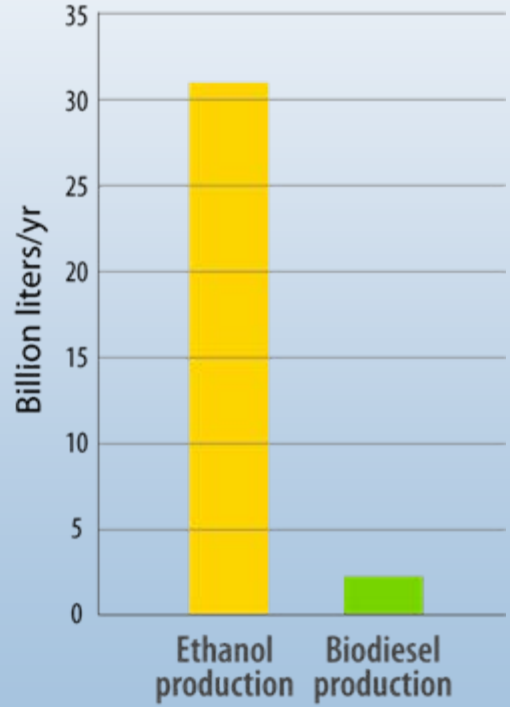
Existing Capacity* – GW



*Does not include hydropower

Transport Fuels

Billion liters/year



Source: REN21 Renewables 2005 Status Report,

Wind

Today's Status in U.S.:

- 9,200 MW installed as of Dec 2005
- Cost 6-9¢/kWh at good wind sites with no PTC

U.S. DOE Cost Goals:

- 3.6¢/kWh, onshore at low wind sites by 2012
- 5¢/kWh, offshore in shallow water by 2014

Long Term Potential:

- 20% of the nation's electricity supply
- Major benefits to rural economy

NREL Research Thrusts:

- Low wind speed technology
- Advanced rotor development
- Utility grid integration

Source: U.S. Department of Energy, Wind Power Monthly January 2006

Where is Wind Energy Going?

Today 2005

Bulk Power Generator
4-6¢ at 15mph

- Land Based
- Bulk Electricity
- Wind Farms

Potential 20% of Electricity Market

Tomorrow

Land Based Electricity Path → **Land Based LWST Large-Scale 2–5 MW** → **Transmission Barriers** → **LWST Turbines:**
- 3¢/kWh at 13mph
- Electricity Market

2012

Offshore Electricity Path → **Offshore Turbines 5 MW and Larger** → **Cost & Regulatory Barriers** → **Offshore LWST Turbine:**
- 5 cents/kWh
- Shallow/***Deep*** *water*
- Electricity Market
- Higher wind Sites

2012 and Beyond

Advanced Applications Path → **Land or Sea Based:**
- **Hydrogen**
- **Clean Water**

→ **Cost & Infrastructure Barriers** → **Custom Turbines:**
- Electricity
- H2 production
- Desalinate water
- Storage
- Multi-Market

2030 and Beyond

Biopower

Today's U.S. status:

- 2004 Capacity – 10 GWe
  - 5 GW Pulp and Paper
  - 2 GW Dedicated Biomass
  - 3 GW MSW and Landfill Gas
- 2004 Generation – 60 TWh
- Cost 8¢-10¢/kWh

Long-term potential:

- Cost 4-6¢/kWh for integrated gasification combined cycle
- 160 TWh of net electricity exported to grid from integrated 60 billion gal/yr biorefinery industry by 2030

Source: Aden,et. al, NREL/TP-510-32438

Biofuels

U.S. Biofuels status

- Biodiesel – 75 million gallons (2005)
- Corn ethanol
  - 81 commercial plants
  - 3.9 billion gallons (2005)
  - Today's cost ~$1.35/gallon of gasoline equivalent (gge)
- Cellulosic ethanol
  - Projected commercial cost ~$3.00/gge

Potential

- 2012 goal – cellulosic ethanol ~$1.42/gge
- 2030 goal – all ethanol = 30% of transportation fuels

NREL Research Thrusts

- The Biorefinery
- Solutions to under-utilized waste residues
- Energy crops

Source: U.S. Department of Energy, National Biodiesel Board, Renewable Fuels Association

Geothermal

Today's U.S. Status:
- 2,800 MWe installed, 500 MWe new contracts
- Cost 5-8¢/kWh with no PTC
- Capacity factor typically > 90%, base load power

U.S. DOE Cost Goals:
- <5¢/kWh, for typical hydrothermal sites by 2010
- <5¢/kWh, for enhanced geothermal systems by 2040

Long Term Potential:
- 40,000 MWe installed by 2040
- Ultimate potential to supply a significant portion of domestic electricity

NREL Research Thrusts:
- Low temperature conversion cycles
- Better performing, lower cost components
- Innovative materials

Source: NREL 2006

Solar

Photovoltaics and Concentrating Solar Power

U.S. Solar Status:

PV
- 450 MW
- Cost 18-23¢/kWh

CSP
- 355 MW
- Cost 12¢/kWh

Potential:

PV
- 11-18¢/kWh by 2010
- 5-10 ¢/kWh by 2015

CSP
- 8.5¢/kWh by 2010
- 6¢/kWh by 2015

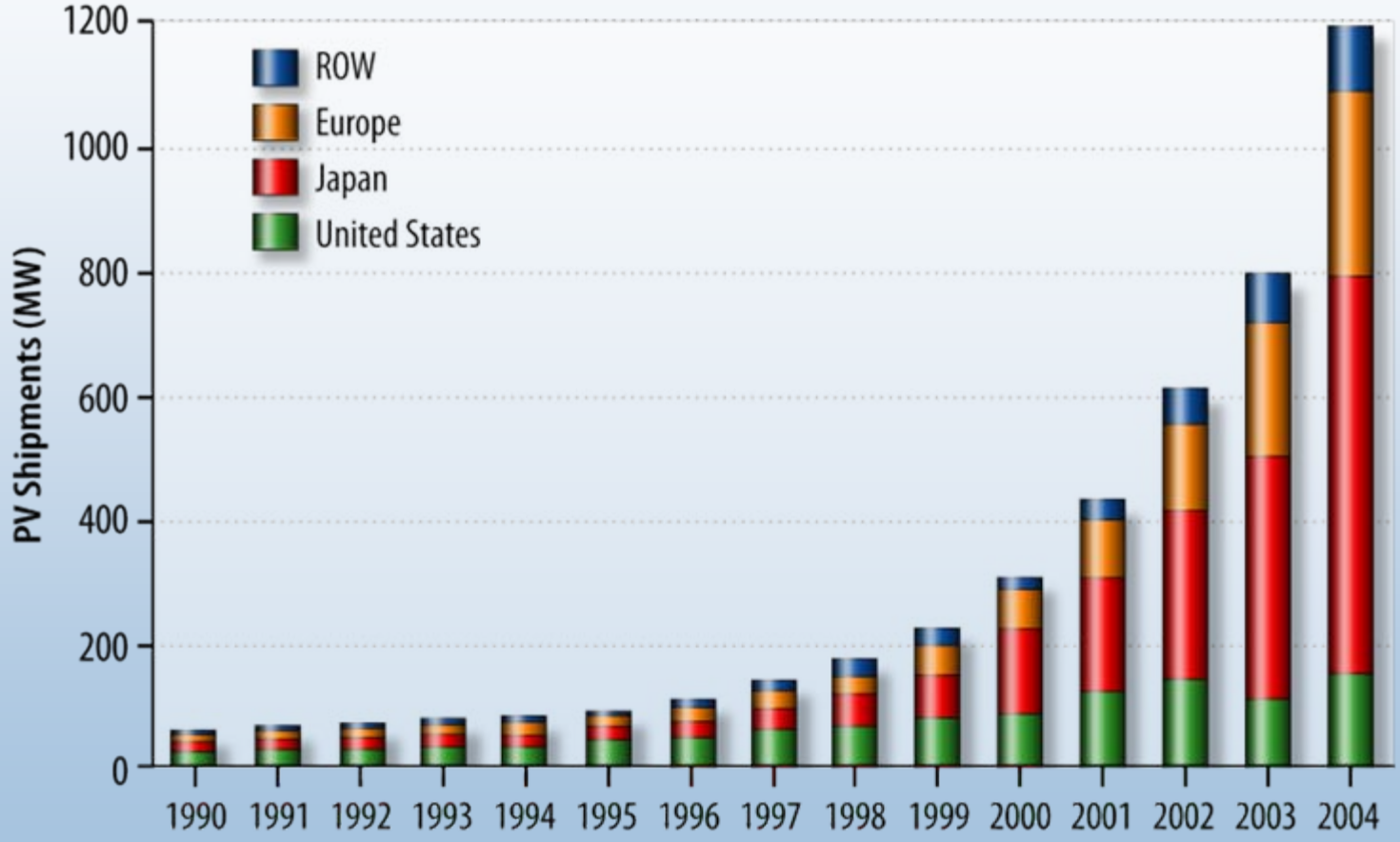
NREL Research Thrusts:

PV
- Advanced manufacturing techniques
- Higher efficiency devices
- New nanomaterials applications

CSP
- Next generation solar collectors
- High performance, high efficiency storage

Source: U.S. Department of Energy, NREL
Updated 5/15/06

Worldwide PV Shipments

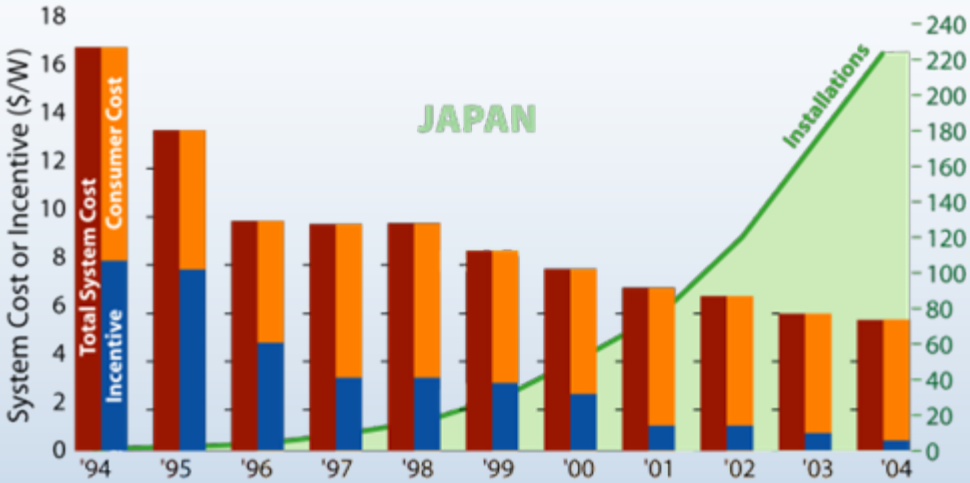


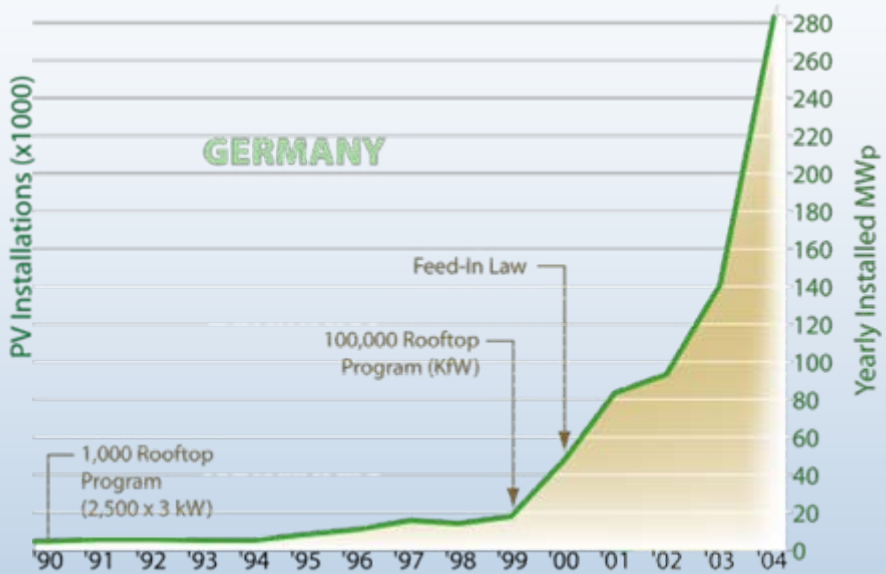
Source: Paul Maycock, PV News, February/March 2005.

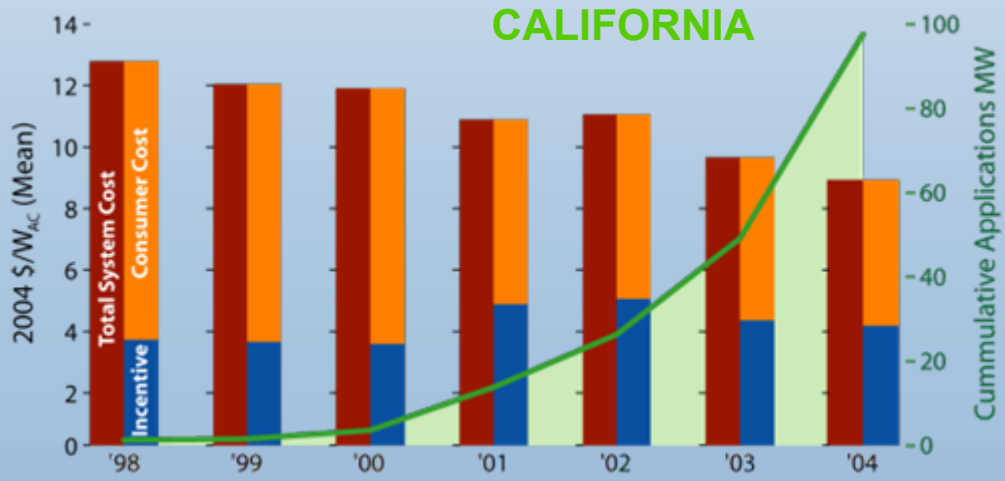
Policy

Stimulates markets

Federal, state, and local governments are the STEWARDS





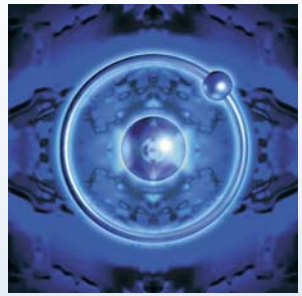


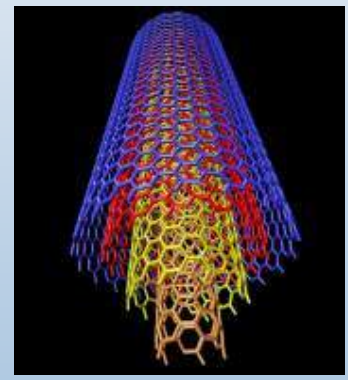
"BIG 3" Experience

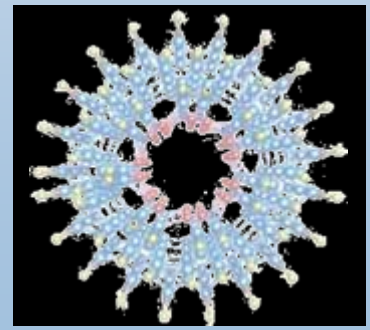
(It works . . .!)

Directions in Energy Science and Technology: The Future Promise

- Supercomputers
- Genomics
- Nanoscience
- Fusion applications
- Cellulosic and biofuels applications
- Hydrogen

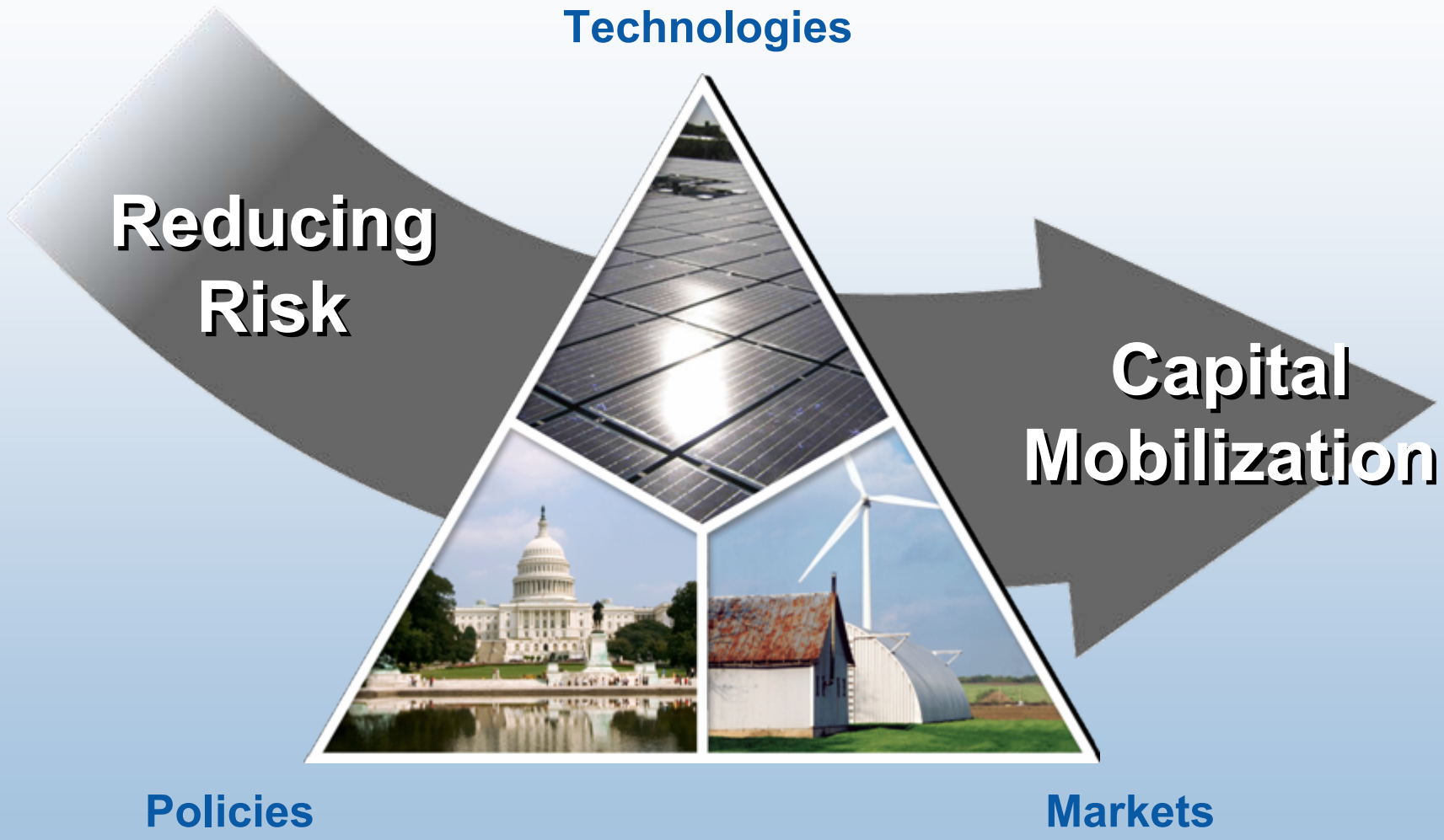






Nano/Bio/Info

Getting There Involves…



The U.S. Department of Energy's

National Renewable Energy Laboratory

www.nrel.gov

Golden, Colorado