

# Humankind's Detour towards Sustainability

## Past, Present, and Future of Renewable Energies

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## Introduction

### **The Crucial Role of Renewable Energies in a Sustainable Global Economy**

- I. International Legislative Decisions and Political Promises Regarding Sustainability
- II. U.S. Legislation Concerning Renewables
- III. History, Present, and Future of Renewables
- IV. Benefits of Renewable Technologies

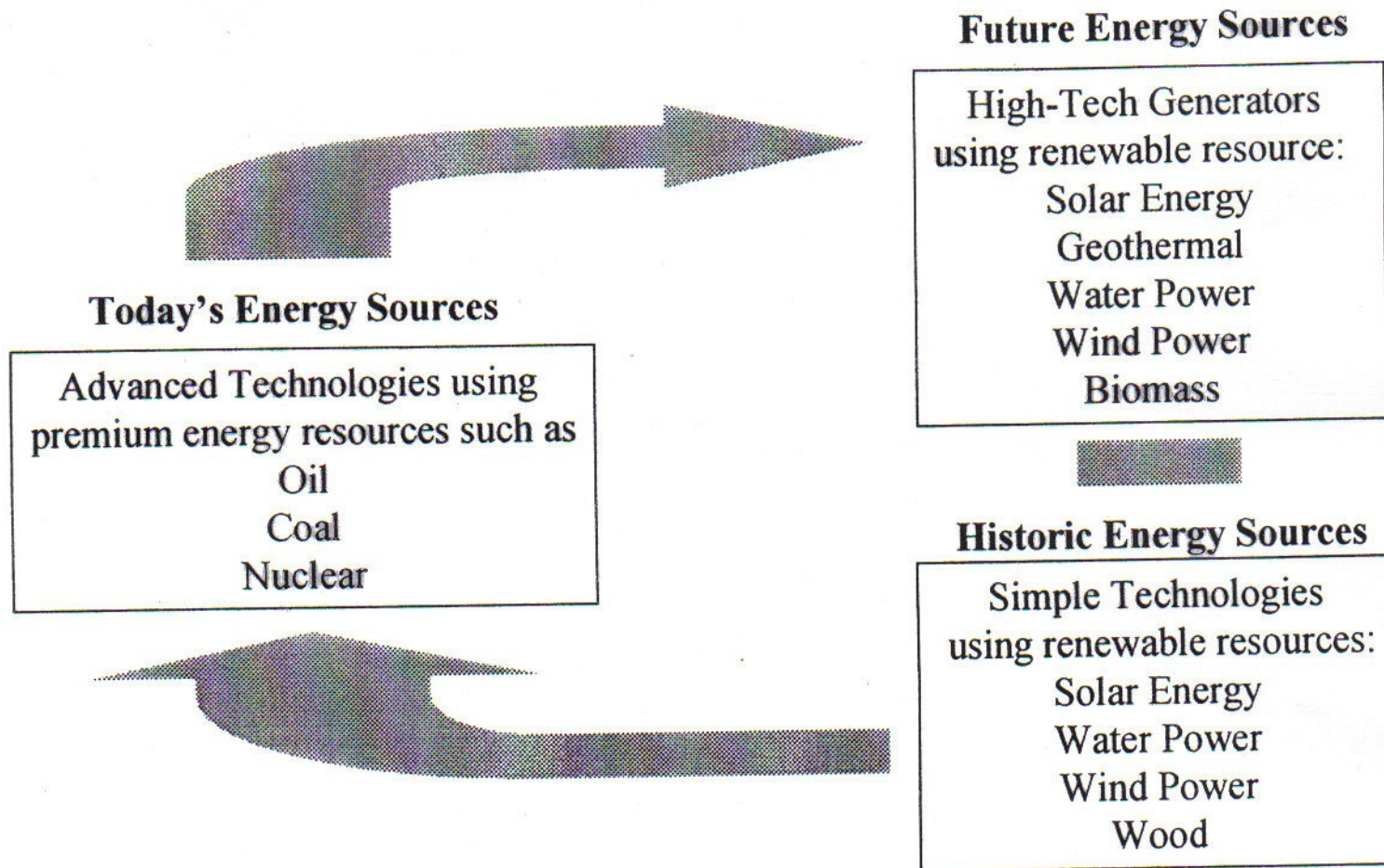
### **Economics of Renewable Technologies**

- I. The role of renewables in a Distributed Energy System
- II. The Key Issue: Prices
- III. Econometric Analysis to Quantify the Assets of Renewable Energies
- IV. Renewable Technologies Create Jobs

### **Renewables for Developing Countries**

### **Outlook: Approaching Sustainability**

# Primary World Energy Sources Over Time



# The Crucial Role of Renewable Energies in a Sustainable Global Economy

- I. International Legislative Decisions and Political Promises Regarding Sustainability
- II. US Legislation Concerning Renewables
- III. History, Present, and Future of Renewables
- IV. Benefits of Renewable Technologies

# I. International Legislative Decisions and Political Promises Regarding Sustainability

- ▶ United Nations Conference on Environmental and Development (Rio de Janeiro, 3-14 June, 1992)
  - Agenda 21
- ▶ Earth Summit +5 (New York, 23-27 June, 1997)
  - Today's global economy still far from meeting goals of Rio
  - Developing countries still struggling against poverty and high population growth
  - Industrialized countries (USA, Japan) not willing to set emission standards

## II. US Legislation Concerning Renewables

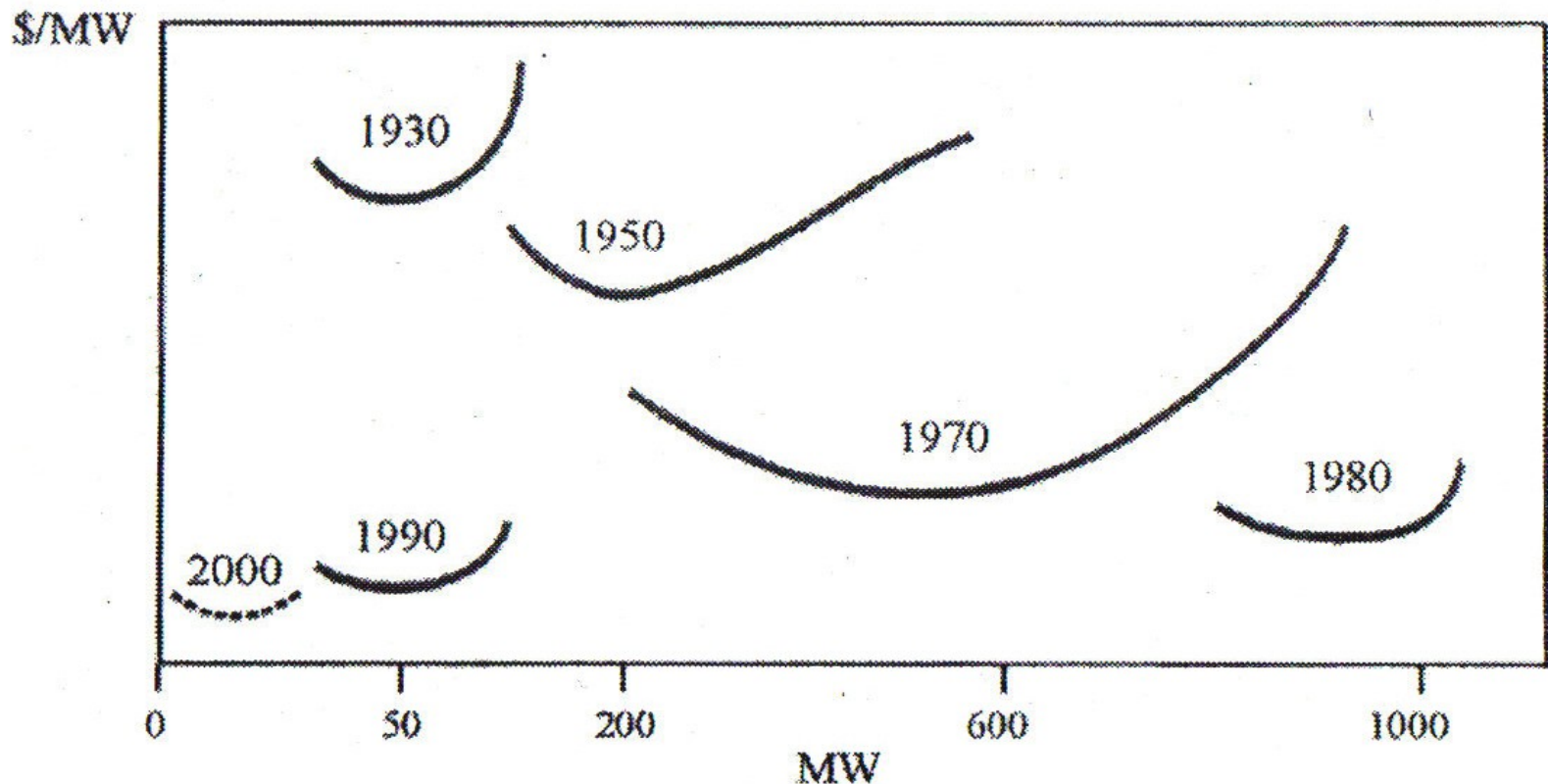
- ▶ Public Utility Regulatory Policies Act (PURPA, 1978)
  - Created a new class of non-utility generators: small power producers (usually used renewable resources)
- ▶ Clean Air Act Amendments of 1990 (CAAA)
- ▶ Reduction of emissions of electricity generation
- ▶ Energy Policy Act of 1992 (EPACT)
  - Created a new category of electricity producers, the exempt wholesale generators (not only renewables)
- ▶ California's Assembly Bill 1890 (AB 1890)
  - Deregulated the electricity industry
  - Set up guidelines for funding of renewable energies



# III. History, Present, and Future of Renewables

- ▶ History: Energy Supply Based On Renewables
  - Wood, water, and wind power
- ▶ Industrialization: Shift to Coal, Oil, and Gas
  - Higher energetic value
  - Promise of cheap and unlimited fossil fuels
  - Nuclear power promised to be “too cheap to meter”
- ▶ Future: Shift Back to Renewables
  - Clean, nonpolluting energies
  - No security risk
  - Volatile fossil fuel prices
  - Expensive and dangerous nuclear power, unsolved problem of disposal of nuclear waste

# Optimal Plant Size (per MW Cost Curves 1930-2000)



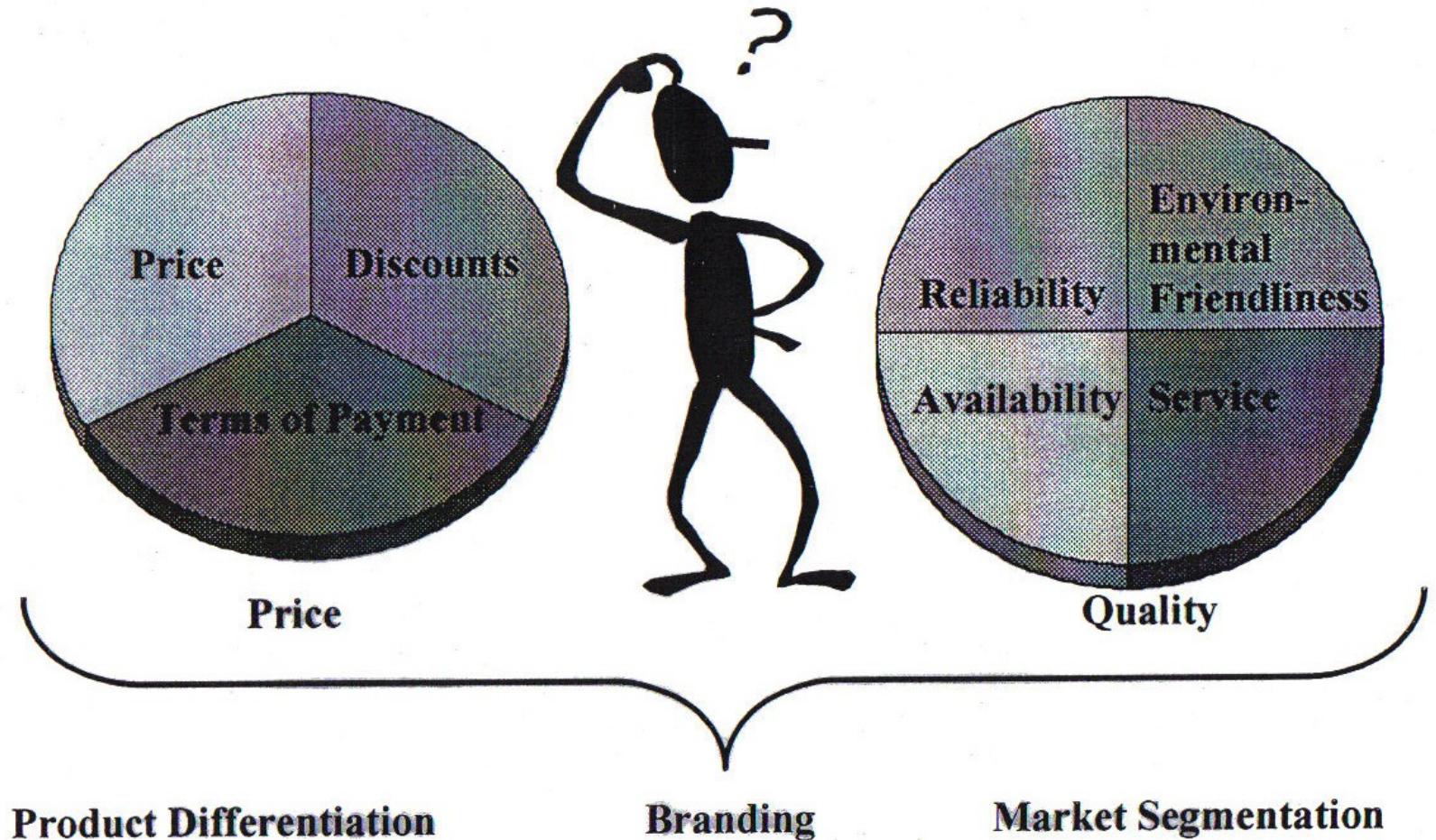
*Source: Bayless, Charles E., Less is more: Why gas turbines will transform electric utilities. In: Public Utilities Fortnightly, Dec 1, 1994.*



# IV. Benefits of Renewable Technologies

- ▶ Renewables Do Not Share Dangers of Fossil Fuels
  - No toxic emissions
  - No nuclear waste
  - No depletion of limited natural resources
- ▶ Advancements in Renewable Technologies
  - Technical efficiencies have improved
- ▶ Economic cost-effectiveness has reached level of cost-competitiveness in many applications
- ▶ Public Support of Renewable Energies
  - Market studies of US indicate a significant number of customers willing to pay higher prices for clean energies
- ▶ Reliability and Environmental Friendliness are Marketable Assets or Renewable Power Generation

# Marketing and Branding in the Electricity Industry



# Economics of Renewable Technologies

- ▶ I. The Role of Renewables in a Distributed Energy System
- ▶ II. The Key Issue: Prices
- ▶ III. Econometric Analysis to Quantify the Assets of Renewable Energies
- ▶ IV. Renewable Technologies Create Jobs

# I. The Role of Renewables in a Distributed Energy System

- ▶ Definition of “Distributed Generation” (INGAA)
- ▶ Renewables are Integral Parts of a Distributed Generation (DG) System
  - Photovoltaics, small wind turbines, and micro hydro generation
- ▶ DG Systems More Reliable than Centralized Power System
  - Major outages less likely to occur due to decentralized generators
- ▶ DG System Provides Higher Quality of Electricity
  - Sin wave pattern of photovoltaics “cleaner” than that of central grid
- ▶ DG as a Holistic Approach
  - Not just replacing central power stations by small distributed power generators
  - First step must be load management to make renewable energy supply feasible



## II. The Key Issue: Prices

### ► Market Distortions through Externalities and State Subsidies

- Actual prices of fossil fuels do not reflect their ecological and social costs
  - Insufficient internalization of external effects such as pollution costs and negative impacts on human health
  - In a regulated environment, federal government bears risk for operating nuclear power plants as well as for nuclear waste disposal
- Subsidies for fossil and nuclear generation technologies
  - Government R&D spending on fossil fuels much higher than on renewables
- If external effects and subsidies for fossil fuels had been taken into account, renewables would have already been cost-effective in many applications for years

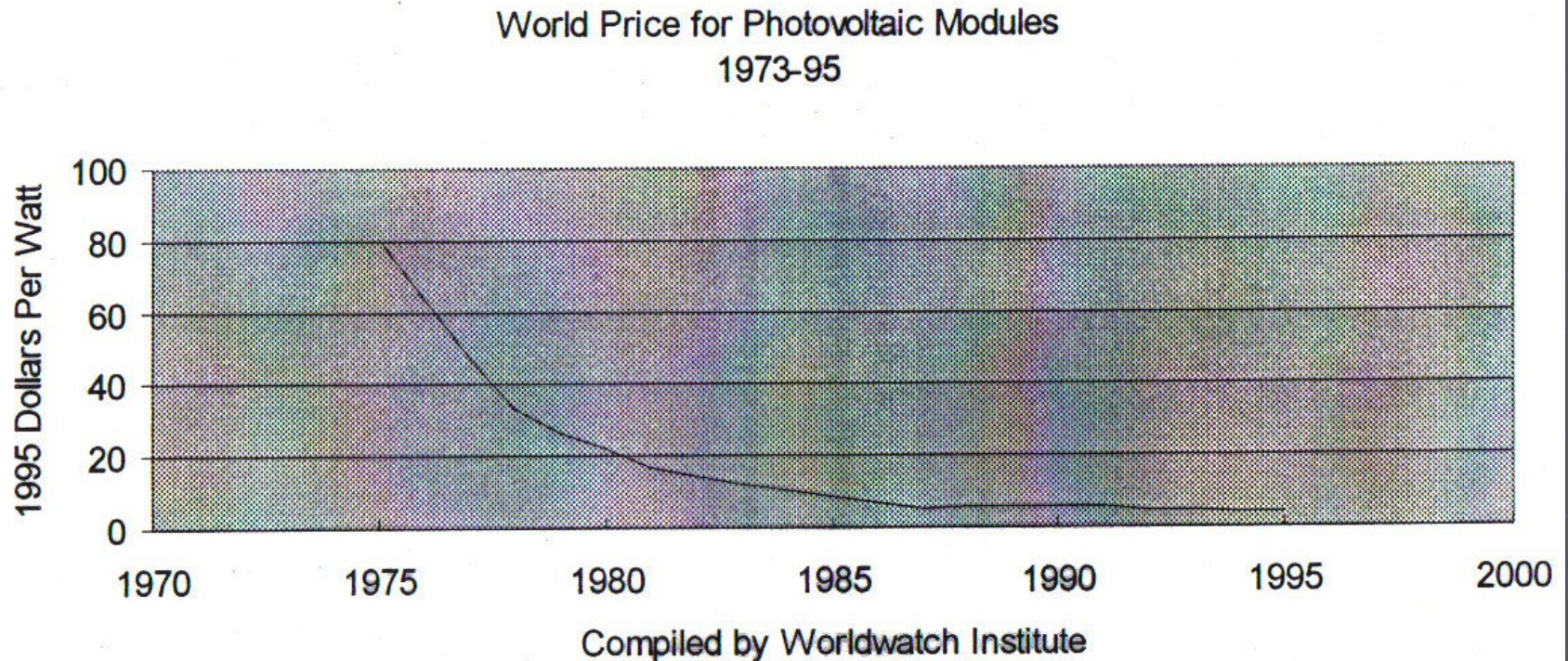
# Government R&D Subsidies for Renewable and Fossil Fuels

<b>Government Research and Development Spending in International Energy Agency Member Countries (Total, 1978-91)</b>		
<i>Technology</i>	<i>Amount (billion 1991 dollars)</i>	<i>Share (percent)</i>
Nuclear Fission	59.8	52
Nuclear Fusion	12.2	11
Gas Turbines	10.9	9
Other Fossil Technologies	14.4	13
Photovoltaics	2.7	2
Other Renewables	7.1	7
End-Use Efficiency	6.6	6
Fuel Cells	1	1
Total	114.7	100

Source: Worldwatch Institute, *Government Research and Development Spending in International Energy Agency Member Countries*. Database Diskette January 1997, File R&D.wk1

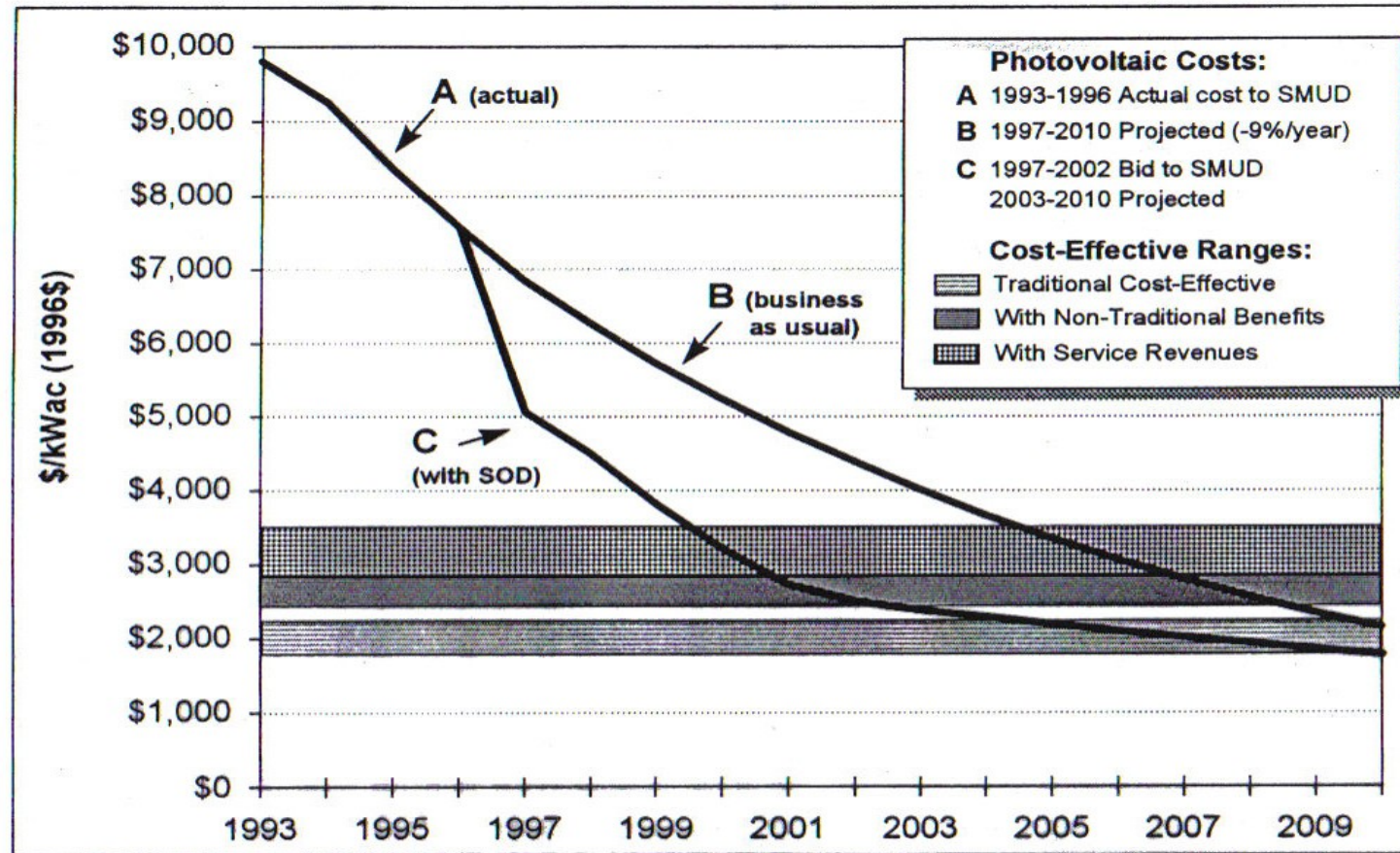


# Photovoltaics as an Economic Viable Renewable Energy Option



Source: Paul Maycock for the Worldwatch Institute, *World Price for Photovoltaic Modules, 1975-95*.  
Database Diskette January 1997, File Solar.wk1

# SMUD's Sustained Orderly Development Strategy (SOD)

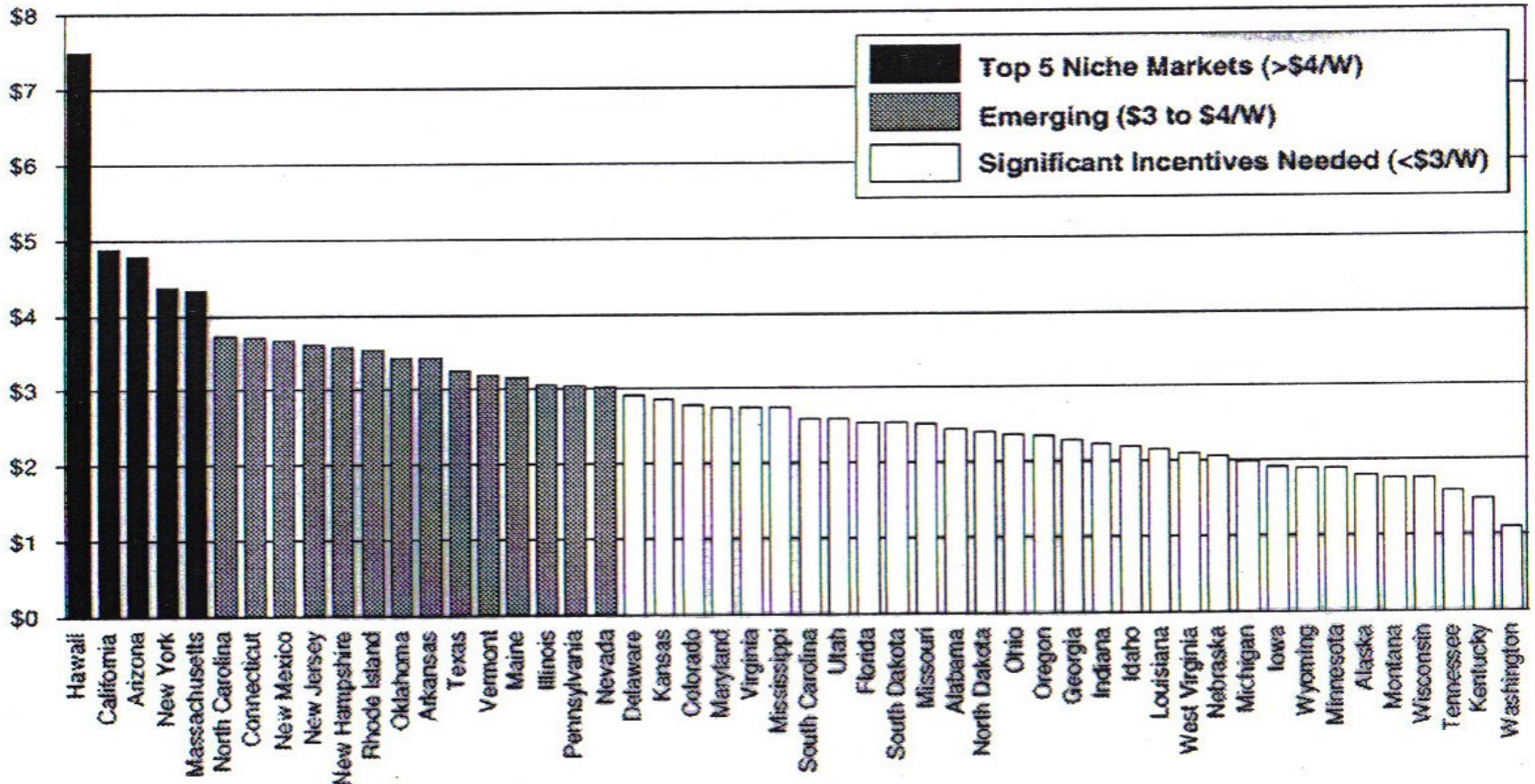


Howard Wenger and Tom Hoff (Pacific Energy Group), and Donald E. Osborn (Sacramento Municipal Utility District), *A Case Study Of Utility PV Economics*. Presented at the American Solar Energy Society's Solar '97 Conference, Washington D.C., April 1997.



# States Ranked by Break-Even PV System Price

Break-Even PV System Price (\$/W)



National Renewable Energy Laboratory (NREL), *Study Reveals Top U.S. Markets for Grid-Connected PV*.  
In: Solar Industry Journal, Third Quarter 1996

# III. Econometric Analysis to Quantify the Assets of Renewables

## ► 1. Risk Management Approach

*Interaction between Uncertainties and Attributes*

Uncertainty	Relevant Attributes
Fuel Price	Operation Costs
Demand	Capability, Availability, Modularity, Location
Environmental Regulations	Externality Costs
Capital Cost	Capital Costs, Modularity, Location
Outages (Supply)	Capability, Availability, Modularity, Location
Market Structure	Costs

Thomas E. Hoff, *Integrating Renewable Energy Technologies in the Electric Supply Industry: A Risk Management Approach*. National Renewable Energy Laboratories (NREL), March 1997.

# Econometric Analysis

- ▶ 2. RMI Cost Analysis (Rocky Mountain Institute)
  - Distributed Generation as least-cost alternative to upgrading existing electricity lines and to prevent line losses by using resources nearer loads
  - Renewable electricity generation cuts peaks and improves reliability of electric power systems
- ▶ 3. Life Cycle Analysis
  - High up-front cost of renewable generation technologies often investment barrier, although in the long run benefits because renewable generation does not have any fuel cost
- ▶ 4. Total Fuel Cycle Approach
  - Calculates costs of all stages (energy mining, processing, transport, storage, generation, end use, and waste disposal)



# IV. Renewable Technologies Create Jobs

- ▶ Renewable Technologies Create New and Additional Jobs
    - R&D, manufacture, construction, financing, operation, maintenance of renewable generation technologies
  - ▶ Study by New York State Energy Office
    - Wind power created 66% more total jobs than natural gas and 27% more jobs than coal
    - Construction and operation of a new coal or nuclear power plant requires 540 workers on average, solar thermal facility 1250 jobs, and wind farms 2700 jobs respectively
- **Renewable technologies could contribute to more jobs than our present energy system based on fossil fuels**



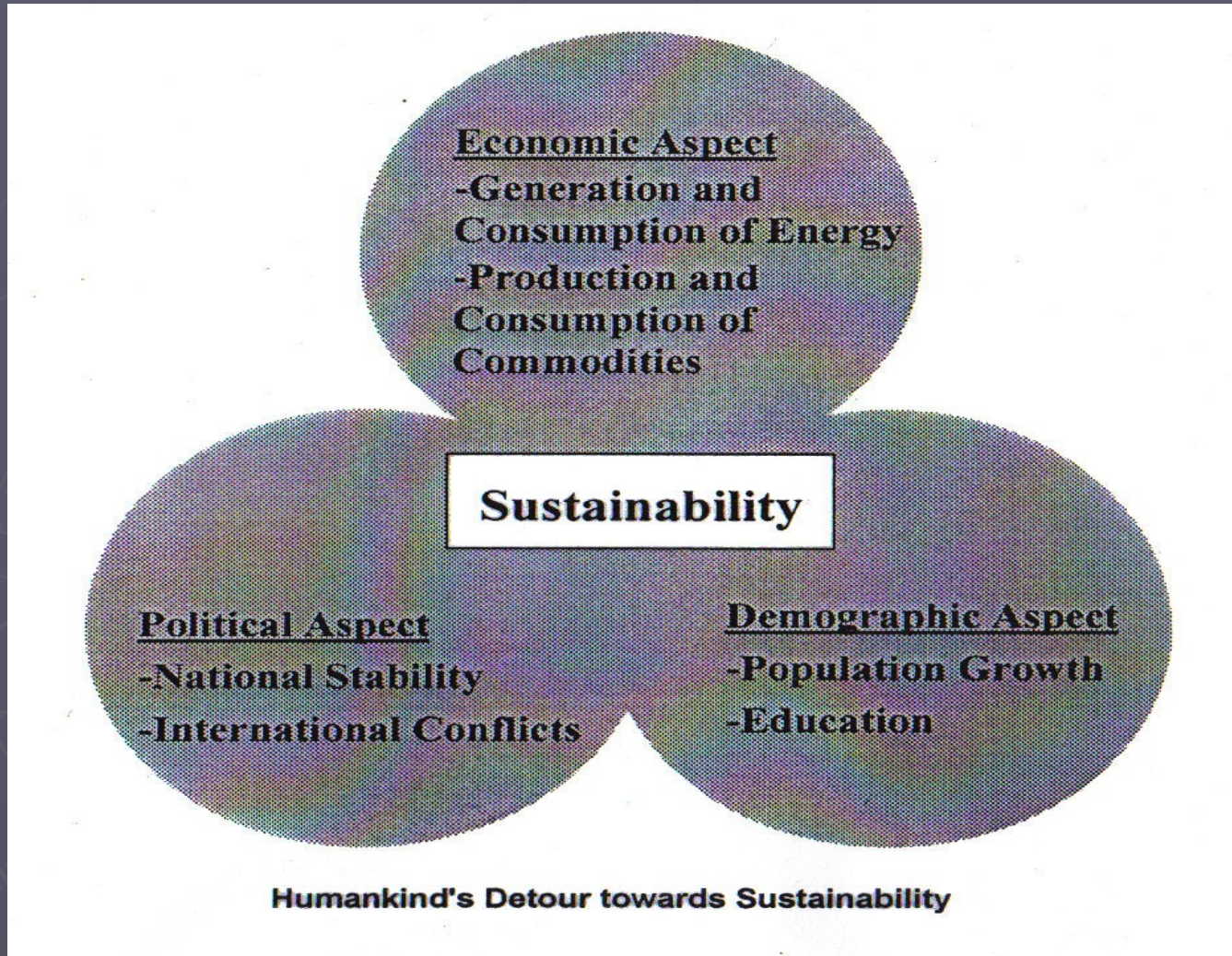
# Renewables for Developing Countries

- ▶ Renewables are an Asset for Developing Countries
  - Often good insolation or small-scale natural water power resources
    - ▶ E.g. solar water heating, micro-hydro and photovoltaic electricity generation
  - Often low coverage of central grid in developing countries, therefore renewables are cost-efficient in many applications already
- ▶ Many Renewable Technologies are Socially Benign
  - Multiple small-scale hydropower systems, as large central hydropower projects did
  - Group of US Indians always refused being connected to the central grid, but willingly accepted their own PV systems
- ▶ Education Important to Sustain Renewable Energy Applications
  - Information, training, and maintenance of the systems

# Outlook: Approaching Sustainability

- ▶ Reaching a Sustainable Global Economy is Not Possible Without Increasing the Share of Renewables of Today's Energy Basis
- ▶ Changing the Structure of the Energy Sector is but a First Step towards Sustainability
  - Not only generation, but also use and consumption of energy has to be sustainable
    - ▶ ***Demand side management, efficiency improvements, and load reduction are crucial issues on the consumer side***
  - Production and consumption of commodities has to be sustained
    - ▶ ***Away from end-of-pipe production philosophy towards input-production pattern***
    - ▶ ***Consumption should demand for ecological and social benign products***
  - Overcoming political, ethnical, and religious conflicts as well as stabilizing the world population are additional prerequisites for sustainability

# Aspects of Sustainability in a Modern Global Economy



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