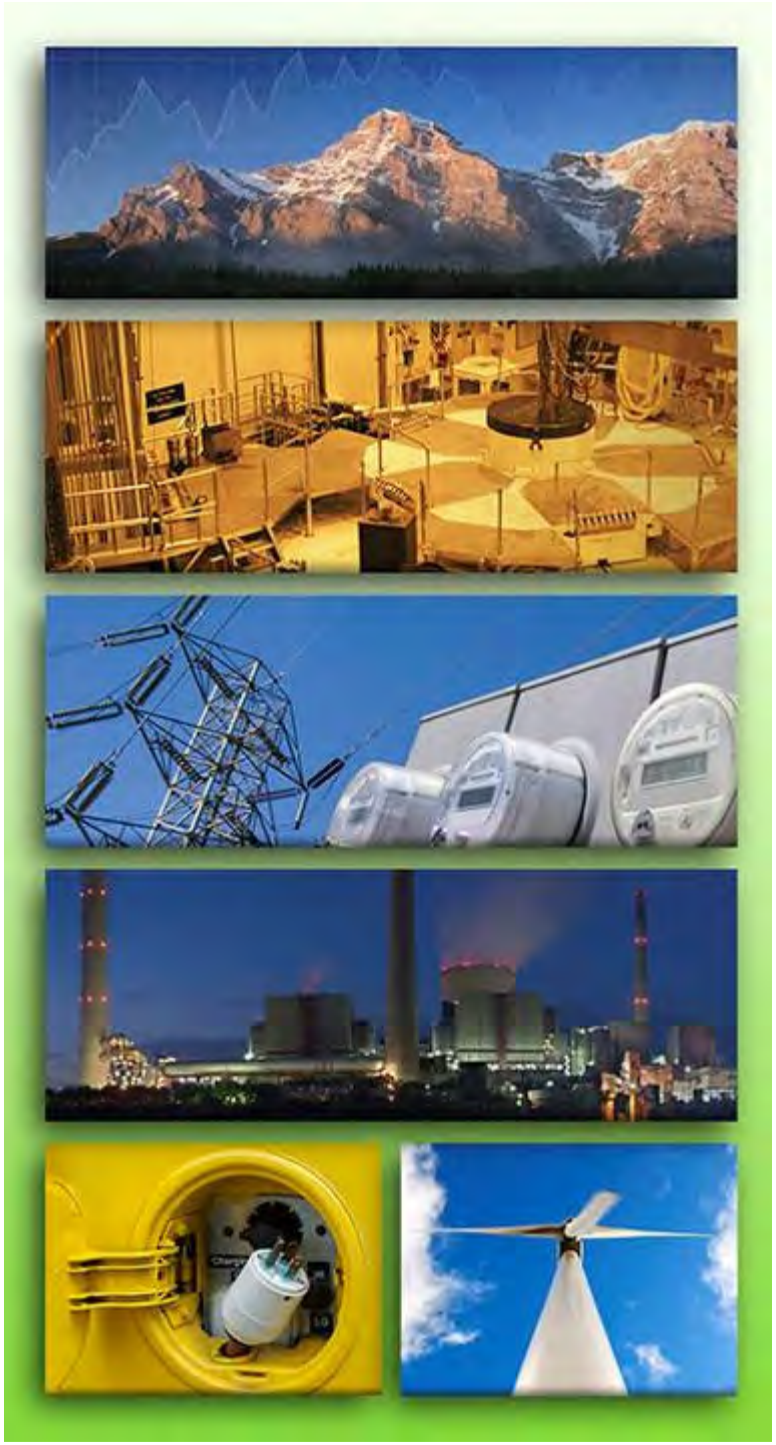

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Making Renewable Energy Work: Future R&D Needs

Bryan Hannegan, Ph.D.
Vice President, Environment & Renewables

Tulane Engineering Forum
April 16, 2010

Our History …

- Founded in 1973
- Independent, nonprofit center for public interest energy and environmental research
- 450+ collaborative participants in more than 40 countries
  - EPRI members generate more than 90% of U.S electricity
- Major offices in Palo Alto, CA; Charlotte, NC; Knoxville, TN
  - Laboratories in Knoxville, Charlotte and Lenox, MA

EPRI's Founder Chauncey Starr

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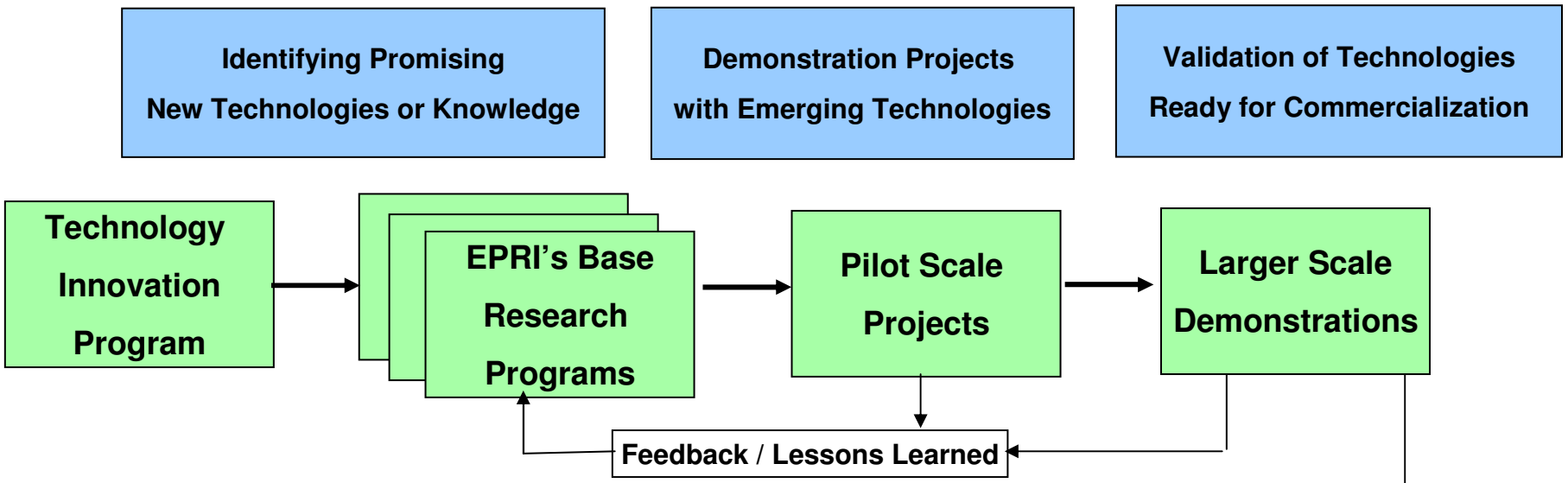
Our Value …



- Scientific Breakthrough
- Novel Ideas Assessment

- Proof of Concept
- Technology Development
- Applications Research
- Bench-Scale Testing

- Component Evaluation
- System Integration

- System Performance
- Scale-up Assessment

Deployment and Commercialization

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EPRI's Research Portfolio

Generation

Fossil Operations & Maintenance

Environmental Controls

Generation Planning

Advanced Coal

Combustion Turbines

Renewables

Nuclear Power

Equipment Reliability

Nuclear Operations & Asset Management

High Performance Fuel

Nondestructive Evaluation

High Performance Workforce

Risk/Safety Mgt

Environment

Air Quality

Global Climate Change

Land & Groundwater

Water & Ecosystems

Electromagnetic Fields (EMF)

Occupational Health & Safety

Power Delivery & Utilization

Transmission

Substations

Grid Reliability

Power Markets

Distribution

IntelliGrid

Energy Utilization

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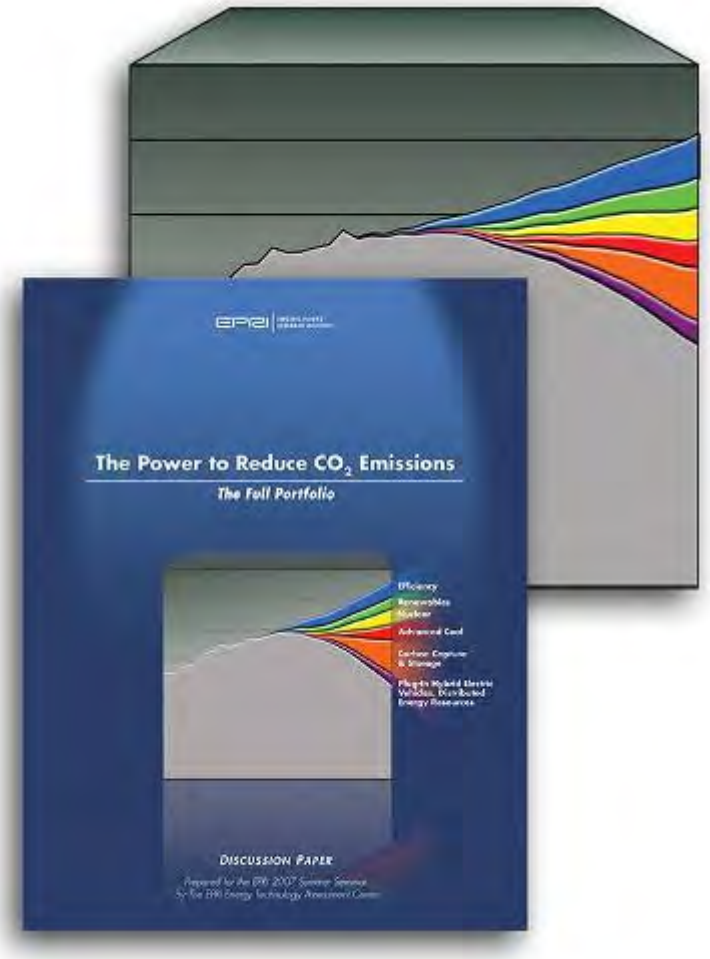
Prism / MERGE Analysis...

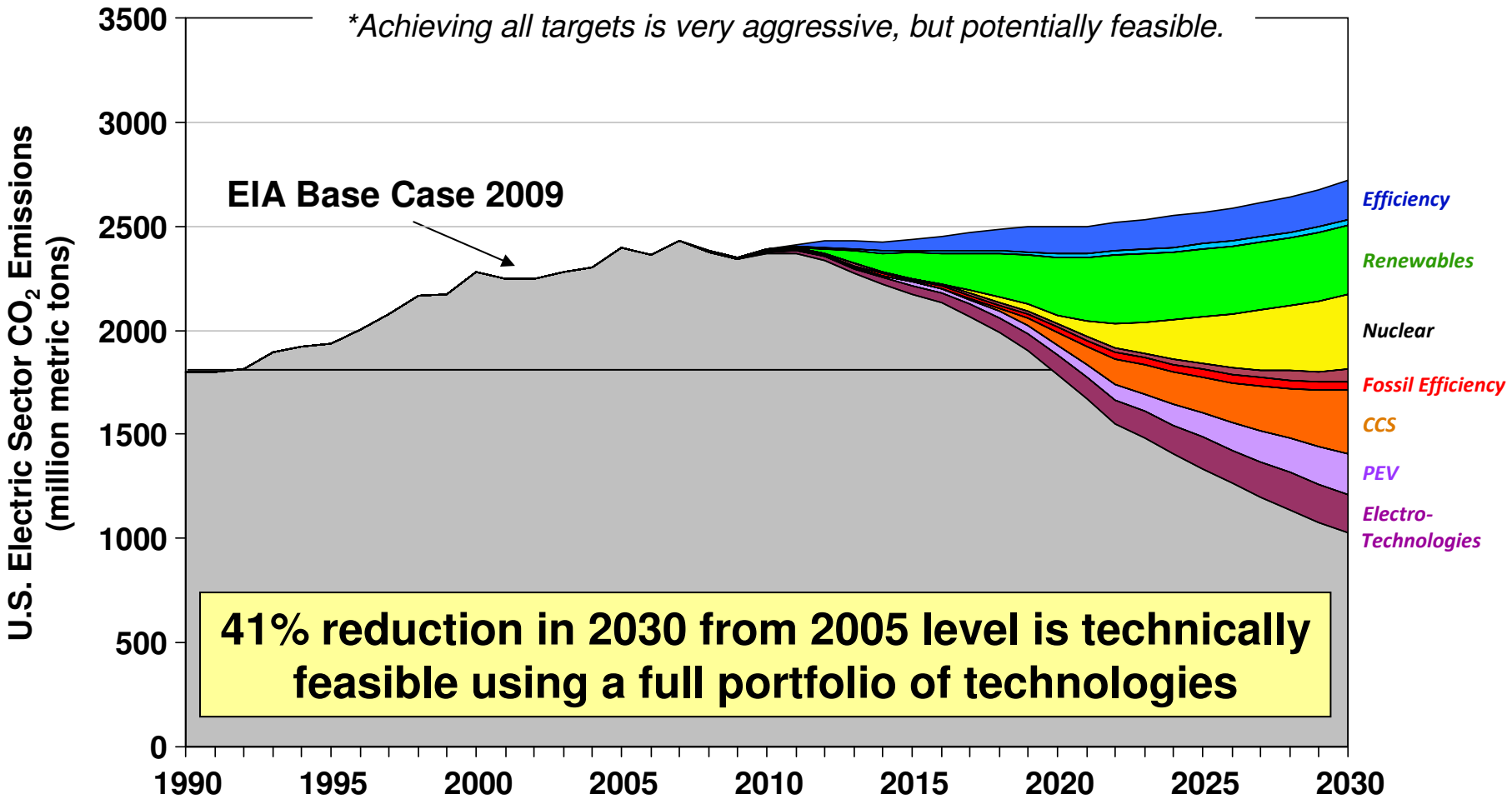
Roadmap for a low-carbon future…

- Detailed analysis of the pathway to reducing CO_2 emissions across the electricity sector
- Provides guidance on the needed generation mix to slow, start and reverse global CO_2 emissions
- Cited in numerous national and international publications



2010 Update In Progress

EPRI PRISM—Potential for CO_2 Reductions



*Energy Information Administration (EIA) Annual Energy Outlook (AEO)

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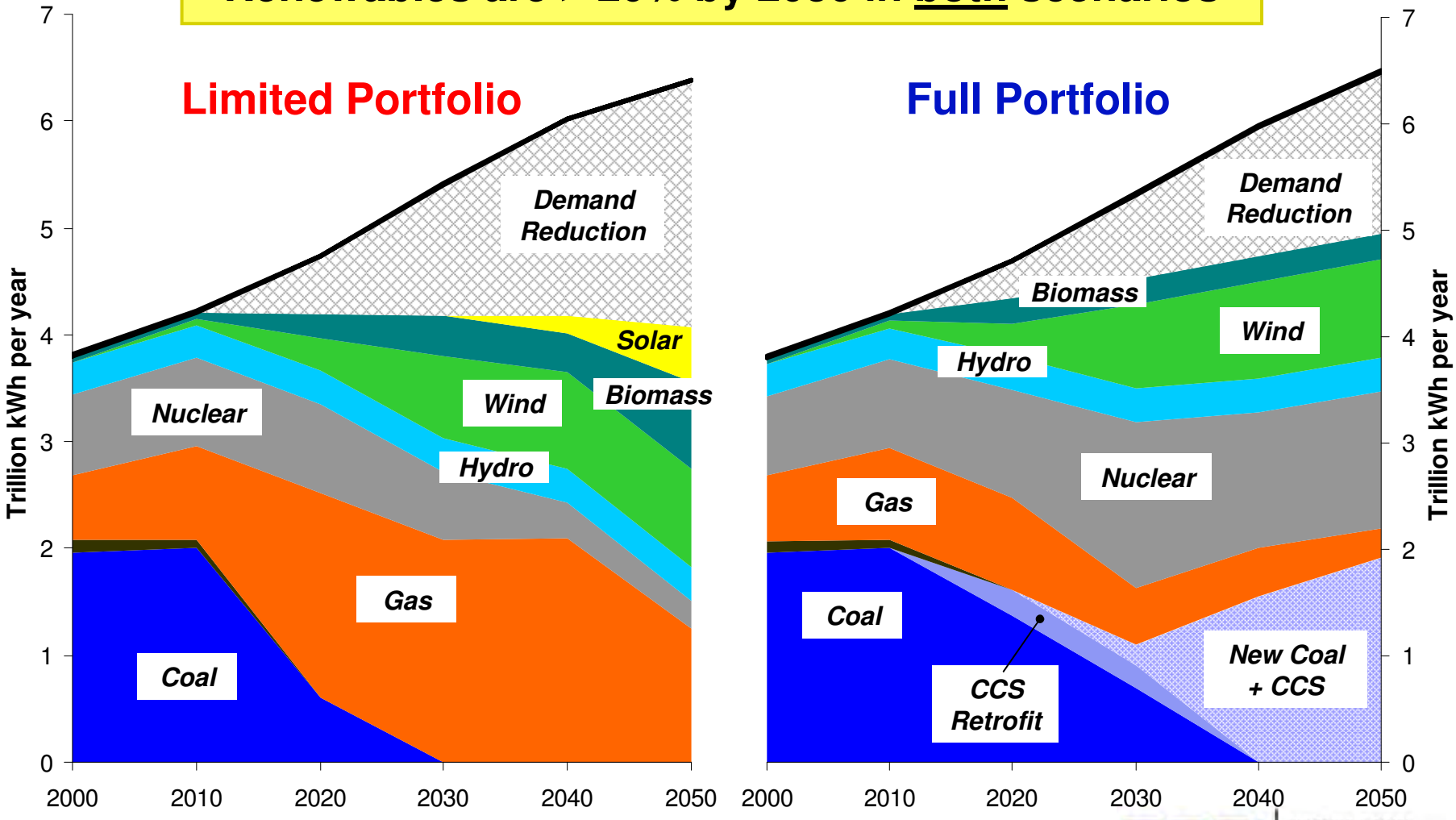
EPRI MERGE – Two Possible Future Mixes

Renewables are > 20% by 2030 in <u>both</u> scenarios



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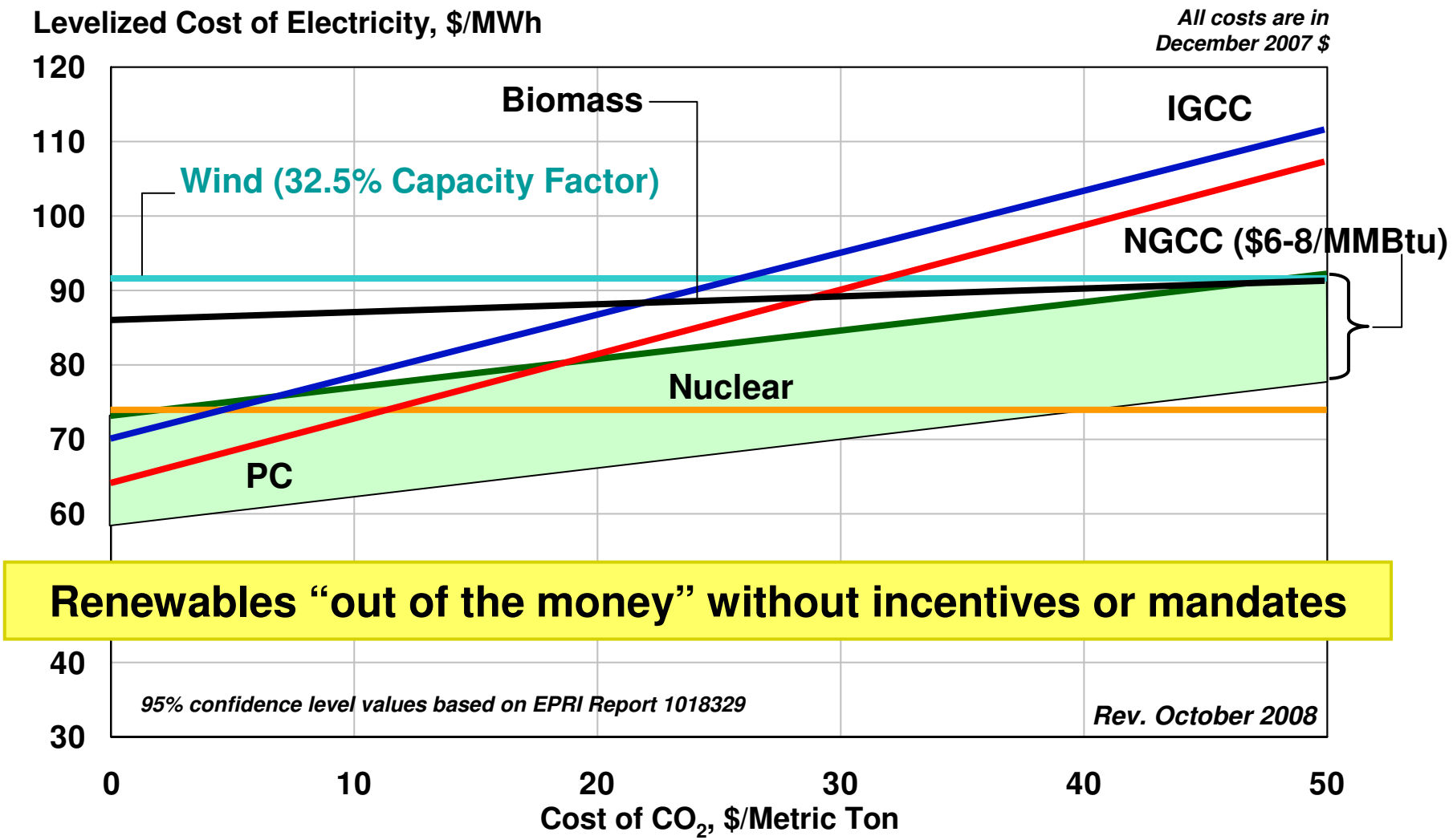
Renewable Energy R&D Needs

- **Reduce Cost of Generation Technology Options**
- **Integrate Variable Generation with Transmission and Distribution**
- **Optimize Energy Storage Capability**
- **Understand and Minimize Environmental Impacts**

Cuts Across Traditional Business Lines

Renewables: The Generation Challenge



Economics & Technology Status

- Renewable Energy Technology Guide
  - Status and potential of renewable technologies
  - Industry trends
- Engineering and Economic Evaluations
- Analysis and Strategy
  - Role of renewables in future generation portfolios
  - Policy scenarios

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Biomass

- Biomass Supply Management
  - Long-term supply security
  - Development of multiple supply chains
  - Assessment of energy plantations
- Power Generation from Biomass
  - Impact on environmental equipment
  - Biomass plant cost database
  - Ash utilization
  - Torrefied wood full-scale tests
  - Methods to increase co-firing fraction
- Life Cycle Analysis of Biomass-Based Power
  - Updated biomass-to-power carbon footprint
  - Land, water implications of biomass supply
  - Broad deployment of biomass power plants: environmental implications

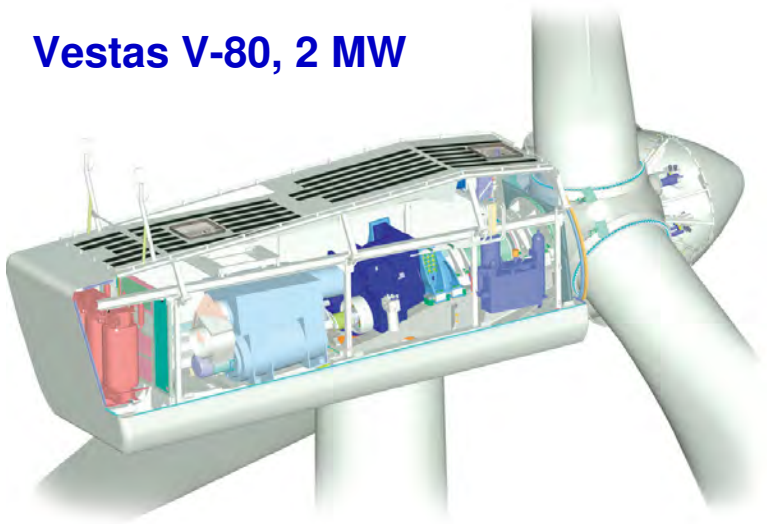
Solar

- Solar Augmented Steam Cycle Applications Analysis
  - Analyze new applications
    - Greenfield
    - Integration with biomass or geothermal
- Solar Technology Acceleration Center (SolarTAC)
  - Benchmark PV/CPV technologies
  - SolarTAC demo projects
- Solar Thermal Storage Technology Assessment
  - Field data for installations
  - Identify hosts for collaborative evaluations of thermal storage performance

Wind

- Wind Power Technology Assessment
  - Drive train, generators, blades, towers, sensors and controls
  - Engineering and economic assessment
- Wind Power Asset Management
  - Status of O&M and asset management technologies
    - Condition Monitoring and NDE
    - O&M procedures
  - Wind turbine asset management guidebook

Vestas V-80, 2 MW



Geothermal

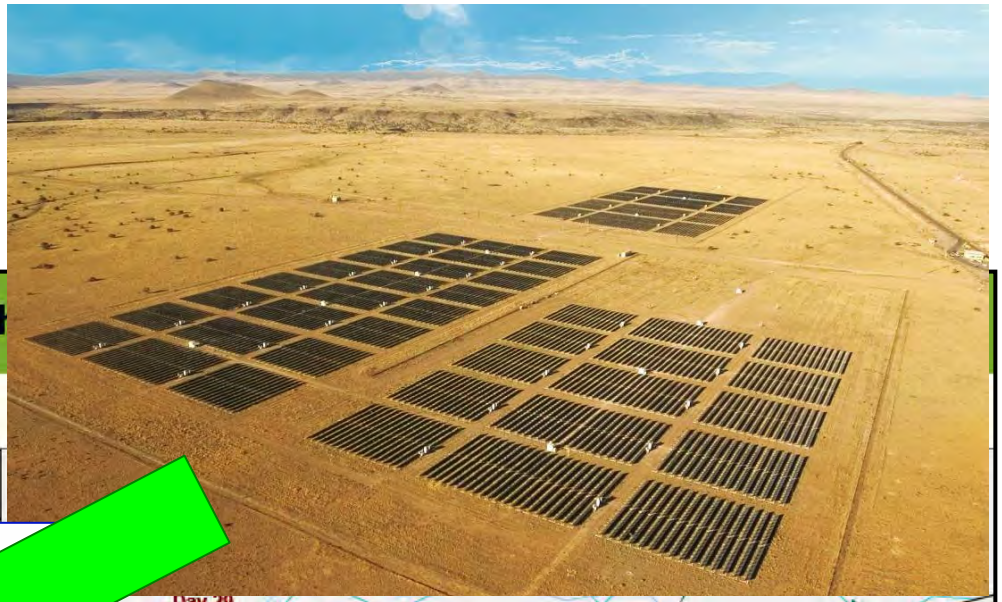
- Geothermal Operations and Maintenance
  - Plant evaluations and assessments
  - O&M handbook
  - Training and technology transfer
- Assessment of Geothermal Power Technologies
  - Engineering and economic analysis of low- and moderate-temperature geothermal resources and technologies
  - Identify demonstration projects for advanced geothermal or EGS

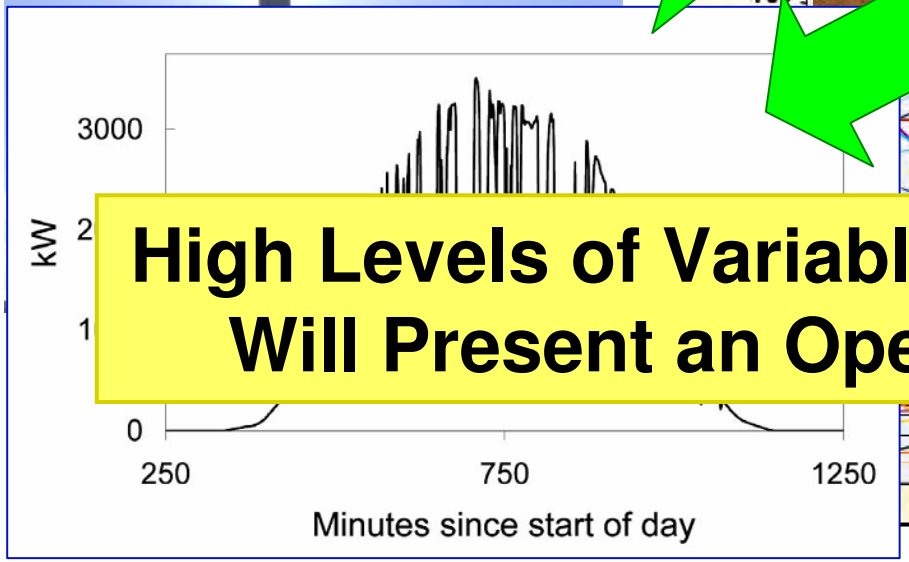
Waterpower

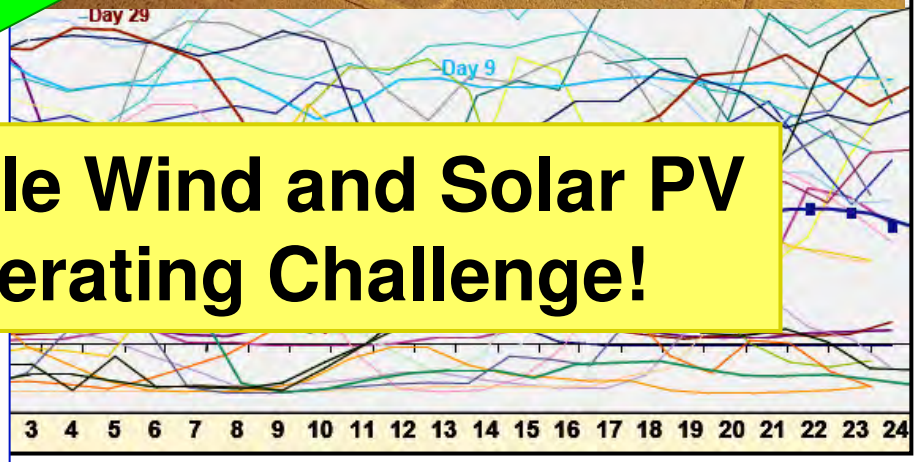
Conventional hydro, ocean, and hydrokinetics

- Waterpower resource assessment
- Generation Issues
  - Technology development
  - Optimization & maintenance
  - Revenue opportunities
- Environmental Issues
  - Advanced turbine development
  - Greenhouse gas research
  - Fish passage & protection
- Ocean & Hydrokinetic Energy Research (Supplemental)

Renewables: The Integration Challenge







High Levels of Variable Wind and Solar PV Will Present an Operating Challenge!

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Integration of Large Scale Renewables

NERC IVGTF Special Report

Defines Reliability Needs

Transmission Development

- New Transmission Planning Tools and Methods to Integrate High Variable Resources

Resource Adequacy

- New Methods to Determine Supply Capacity and Reserve Requirements

Advance Operator Tools

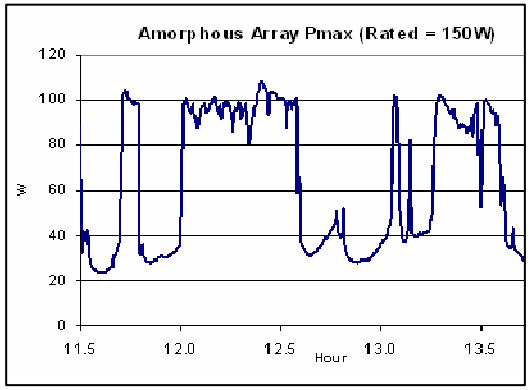
- New Methods to Determine Supply Capacity and Reserve Requirements
- New Operator Decision-Making Tools and Improved Frequency Control Methods

Flexible System Resources

- Technical Performance Specs for VG/DR/PHEV
- Smart Grid Demonstration Projects

Integration of Distributed Renewables

- High Penetration PV Impact on Circuits
  - Model development and system impact evaluation
  - Economic Assessment
  - Demonstration on selected feeders
- Distribution PV Monitoring
  - Understand the performance characteristics under various environmental and climatic conditions
  - Large population of units
  - Monitoring protocol and package
- Operations and Maintenance Needs
  - Assess maintenance practice
  - Develop needs, gap analysis
  - Identify opportunities for improvement



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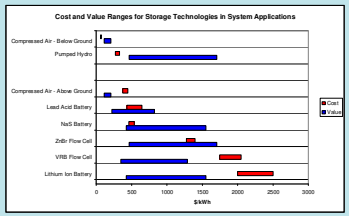
Energy Storage

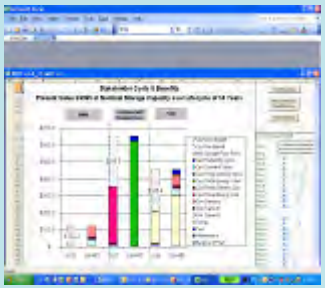
Technology Watch and Strategic Intelligence



Market Analysis

Strategic Intelligence

On-line Assessment Guide

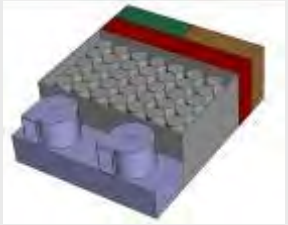


Evaluation Tools

Technology Assessment & Evaluation

Fuel Cells and Flow Batteries

Compressed Air Cycles



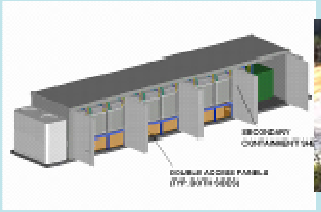
Li-ion Batteries

Thermal Storage Systems

Micro-generation

Testing, Validation and Demonstration

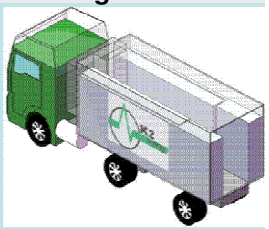
NaS Battery



ZnBr Battery

Large CAES

Li-ion Battery



Mobile Storage Systems

Short-Term → **Long-Term**

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Renewables: The Environmental Challenge

- **Understanding the interaction between the environment and renewable energy technologies**
  - Characterizing the resource
  - Interactions with species and habitat
  - Life cycle analysis
  - Human health and safety
- **Advancing improved approaches**
  - Siting methodologies
  - Technology and operational improvements
  - Mitigation strategies
- **Large scale impacts and limitations**
  - Assess the impacts on harvesting energy at large scales

Working Collaboratively: Solar PV Example

3 Year Strategy
Compile solid data on O&M, Validate and demonstrate value,
Determine realistic cost, & Inform key stakeholders

Federal/State/Labs

U.S. DOE
EIA
National Labs
State Demonstrations

EPRI

Renewables ELT
PDU Sector Council
Distributed Solar ELT
Program Advisory (P174)
Demonstrations
Coordination with DOE/Labs/ Industry

Solar Industry

SEPA
SEIA
SolarTAC
PV/Inverter Manufacturers

Standards Organizations

IEEE
IEC
NIST

Regulatory and Informational

FERC
NERC
NARUC

Key Insights from Recent EPRI Work

- The technical potential exists for the U.S. electricity sector to significantly reduce its CO_2 emissions over the next several decades.
- A low-cost, low-carbon portfolio of electricity technologies can significantly reduce the costs of climate policy.
- No one technology will be a silver bullet – a portfolio of technologies will be needed.
- Renewables must overcome barriers related to cost and performance, integration, and environmental sustainability
- Much of the needed technology isn't available yet – substantial R&D, demonstration is required.

For More Information

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Together…Shaping the Future of Electricity