



Industry Technology Demonstrations - IGCC

Ronald L. Schoff (rschoff@epri.com)
Project Manager, Demonstration Projects

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The Challenge . . .

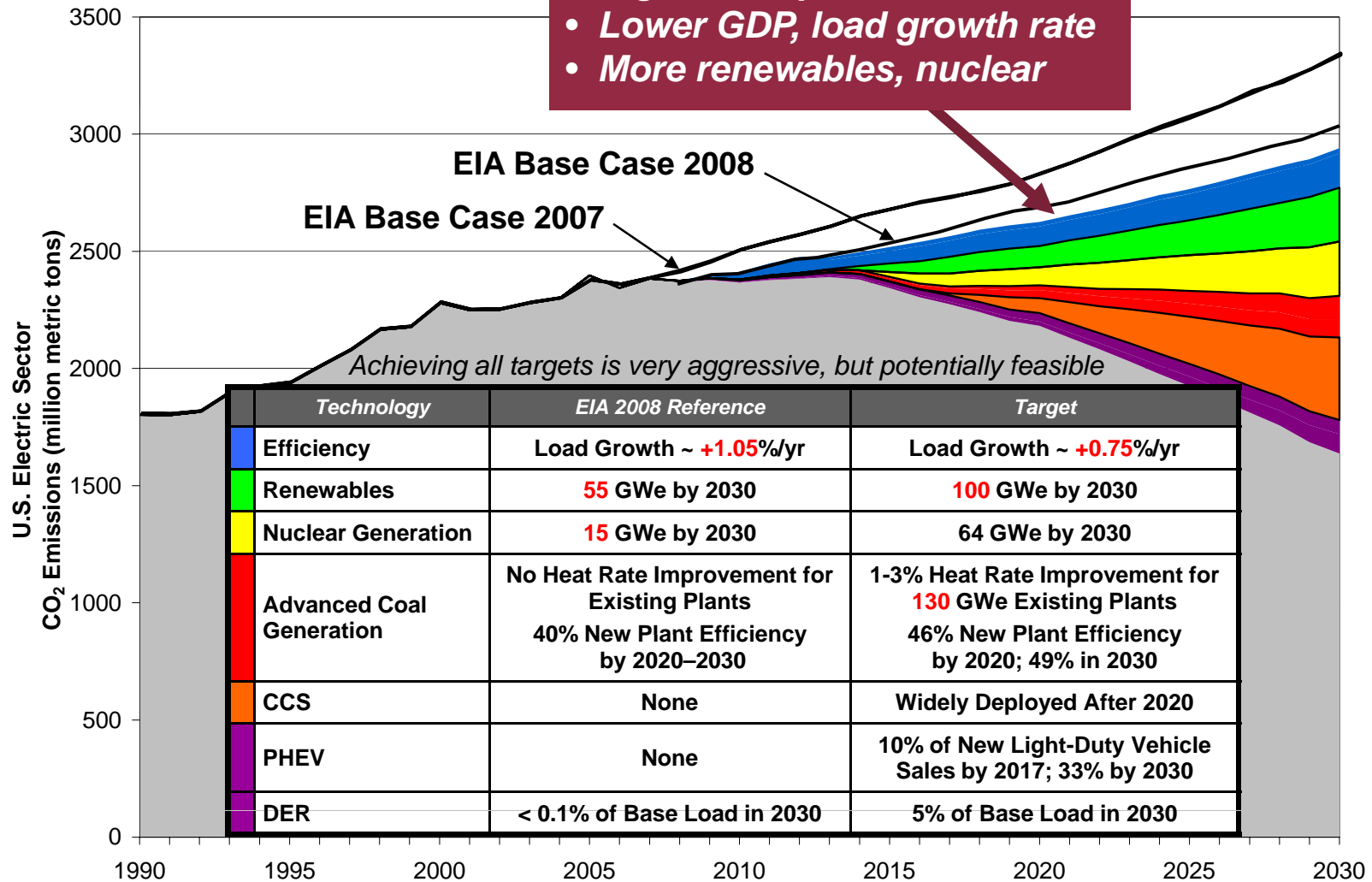
- Growing scientific and public opinion that CO₂ emissions are contributing to climate change...
- Priority of the US Congress ...
- U.S. responsible for 1/4 of global CO₂ emissions...
- Electricity sector responsible for 1/3 of U.S. CO₂ emissions...
- General agreement that technology solutions are needed...



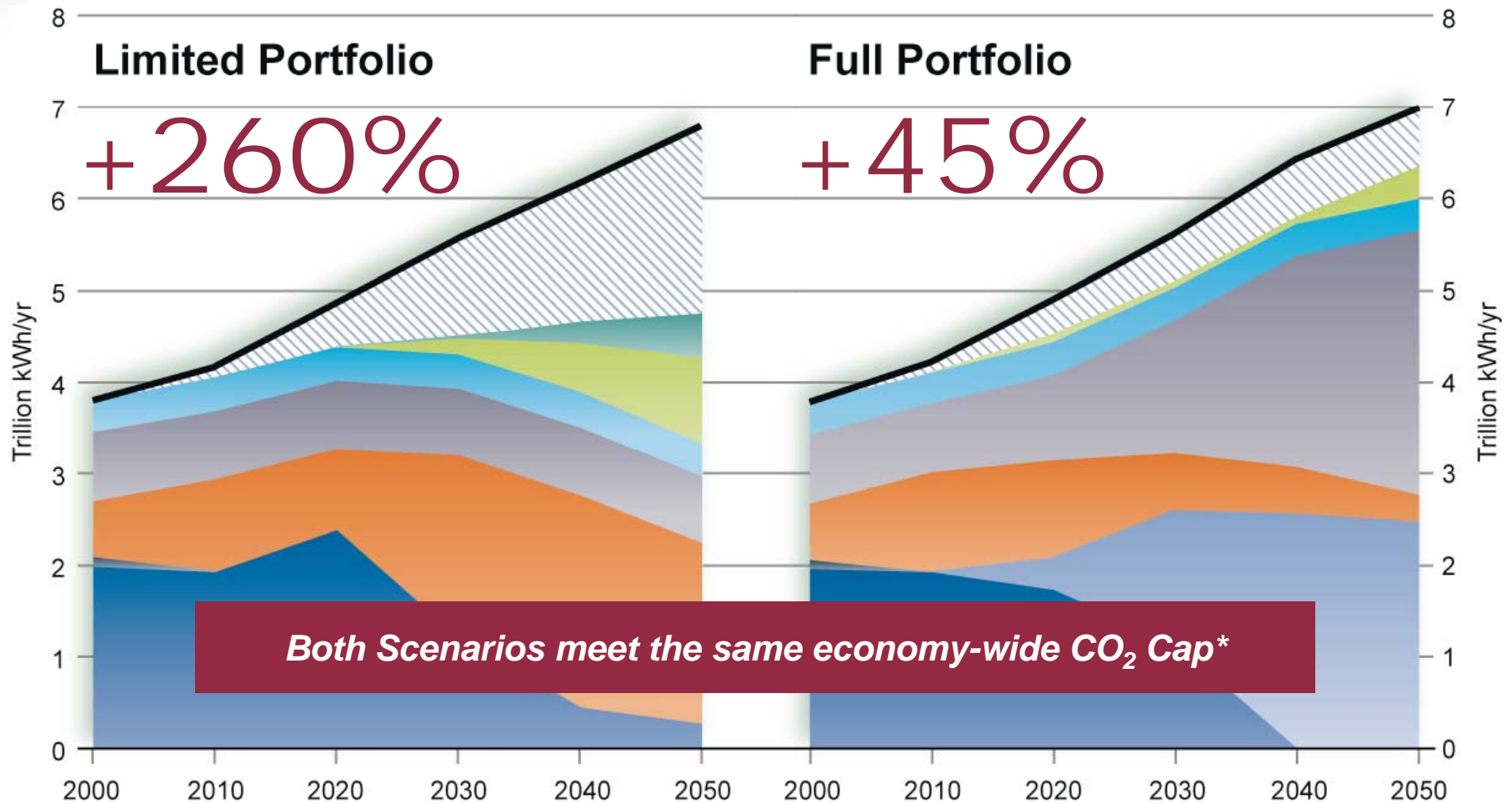
How can the electricity industry respond?

EPRI Prism – 2008 EIA with Energy Bill

- Higher fuel prices
- Lower GDP, load growth rate
- More renewables, nuclear



Increase in Real Electricity Prices... 2000 to 2050

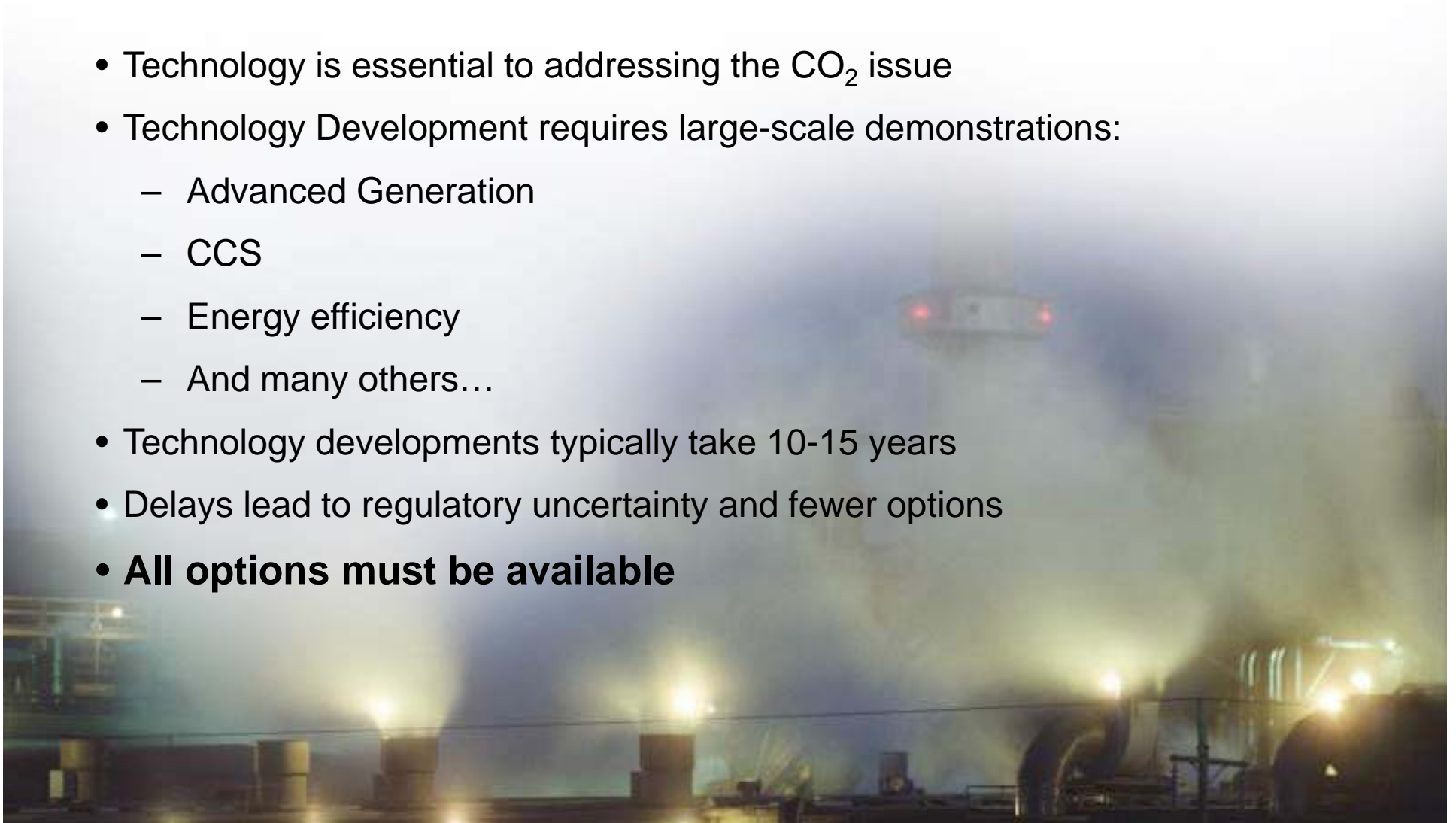


*Economy-wide CO₂ emissions capped at 2010 levels until 2020 and then reduced at 3%/yr

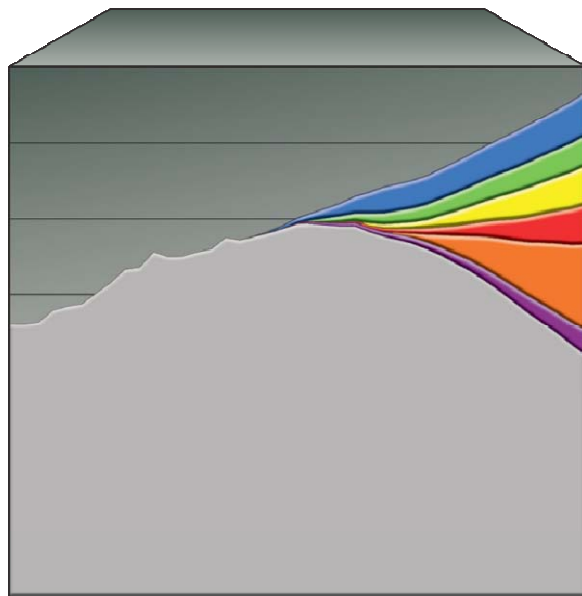
Why Now?

Every year we delay...we fall further behind ...

- Technology is essential to addressing the CO₂ issue
- Technology Development requires large-scale demonstrations:
 - Advanced Generation
 - CCS
 - Energy efficiency
 - And many others...
- Technology developments typically take 10-15 years
- Delays lead to regulatory uncertainty and fewer options
- **All options must be available**



Analysis to Action

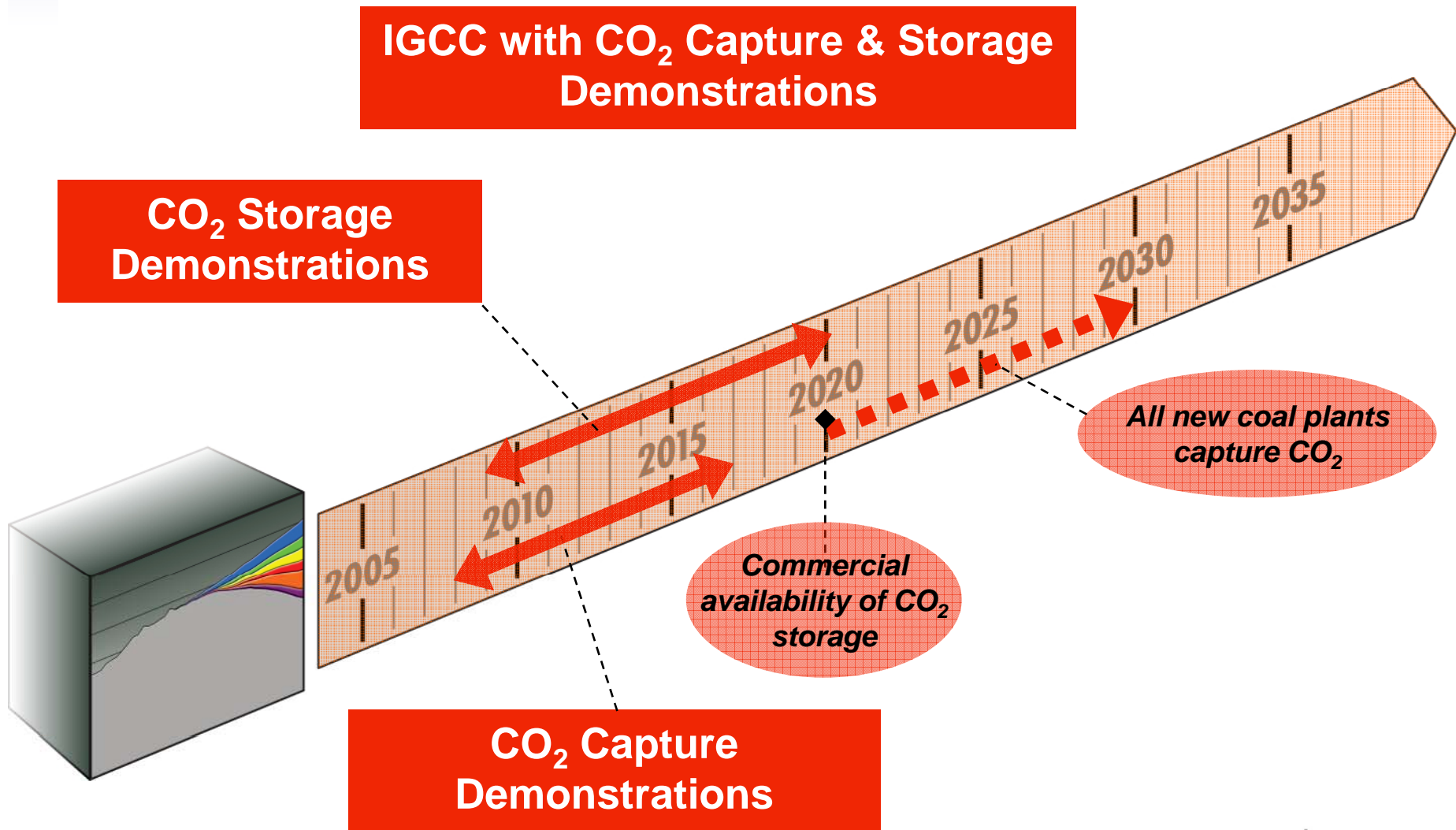


<i>Technology Challenges</i>
1. Smart Grids and Communication Infrastructure
2. Transmission Grids and Associated Energy Storage Infrastructures
3. Advanced Light Water Reactors
4. Coal-Based Generation Units with CO ₂ Capture and Storage

<i>Demonstration Projects</i>
Smart Grids
Energy Efficiency
Compressed Air Energy Storage
Concentrated Solar Power Plant (CSP)
CCS Using Chilled Ammonia
CCS Using a Different Technology
Low-Cost O ₂ Production
IGCC with CCS
Adv. Pulv. Coal Plant – UltraGen I (Future)

Building for the Future

Advanced Coal Plants with CO₂ Capture and Storage

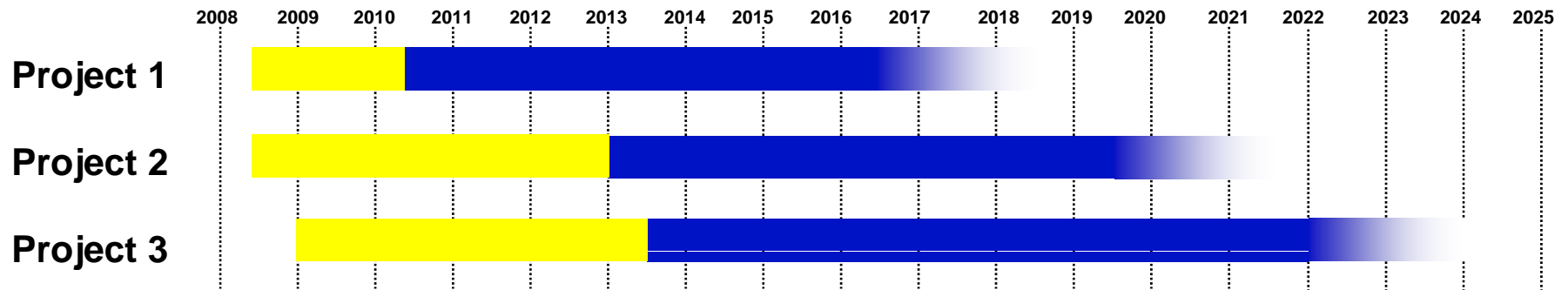


IGCC with CCS Demonstration Initiative

Outline of Projects

- **IGCC with CCS #1**
 - 10–20% capture of CO₂ from syngas at an existing IGCC
- **IGCC with CCS #2**
 - 40–70% CO₂ reduction at an existing or planned IGCC
- **IGCC with CCS #3**
 - 80–90% CO₂ reduction at a new IGCC

IGCC PROJECT SCHEDULE

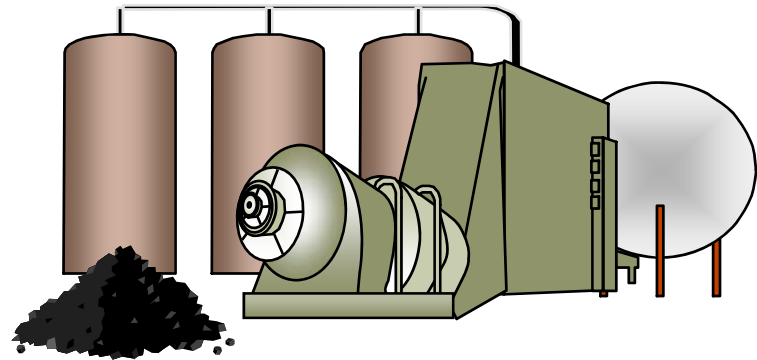


Note: Yellow = Engineering Phases Blue = Project Execution Phases

IGCC with CCS Demonstration Initiative

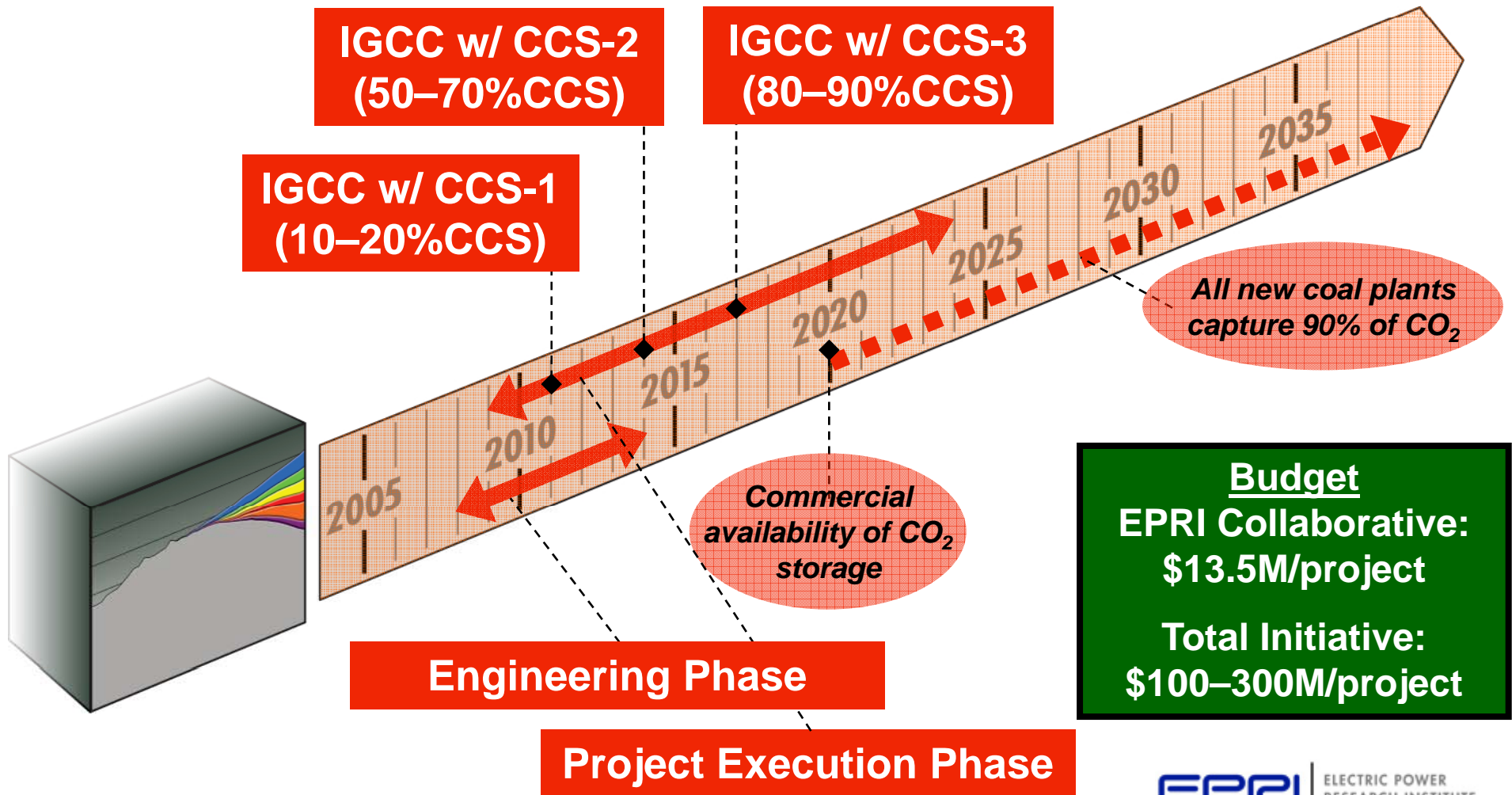
Value To Industry

- **Lower risk** for future IGCC projects with CCS through “real world” demonstrations
- **Advance understanding** of how to integrate IGCC with CO₂ capture and geologic injection
- **Provides design guidelines and economic data** on capture, transport, and storage for immediate use by collaborative members
- Contributes to a range of **compliance options** for power industry as CO₂ regulations emerge
- **Improves public understanding** of IGCC and CCS technology



IGCC with CCS Demonstration Initiative

Project Timeline and Budgetary Estimates



Project Description

- **Pre-commercial-scale development plant of 150 ton-O₂/day unit integrated with 5-15 MW_e turbomachinery system**
 - Utilizes “at scale” ceramic membrane modules for oxygen separation
 - Representative of arrangement for full-scale IGCC plant with CCS
- **Three-year program (Phase 3) to design, build, and test system**
 - Team: Air Products (with Ceramatec, Siemens,...), DOE, and potentially EPRI
 - Host site to be confirmed in 2008
- **EPRI ready to launch collaborative**
 - Builds on major investments by Air Products and DOE
 - Allows incorporation of real-world utility plant design and integration considerations
 - Forms a bridge to commercial IGCC application



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ITM Development Test

Value To Industry



- **Reduces barriers to IGCC technology deployment**
 - Decreases IGCC capital cost by ~7%
 - Decreases auxiliary power consumption by ~6% of gross power
 - Improves overall plant efficiency by ~1 percentage point
 - Reduces oxygen plant footprint by 50%
 - Reduces cooling water requirement by 60%
- **Large forecast growth in oxygen plant market should drive learning-by-doing cost reduction after commercialization**
- **Potential use with oxy-combustion boilers**

How to Improve Oxygen Separation?

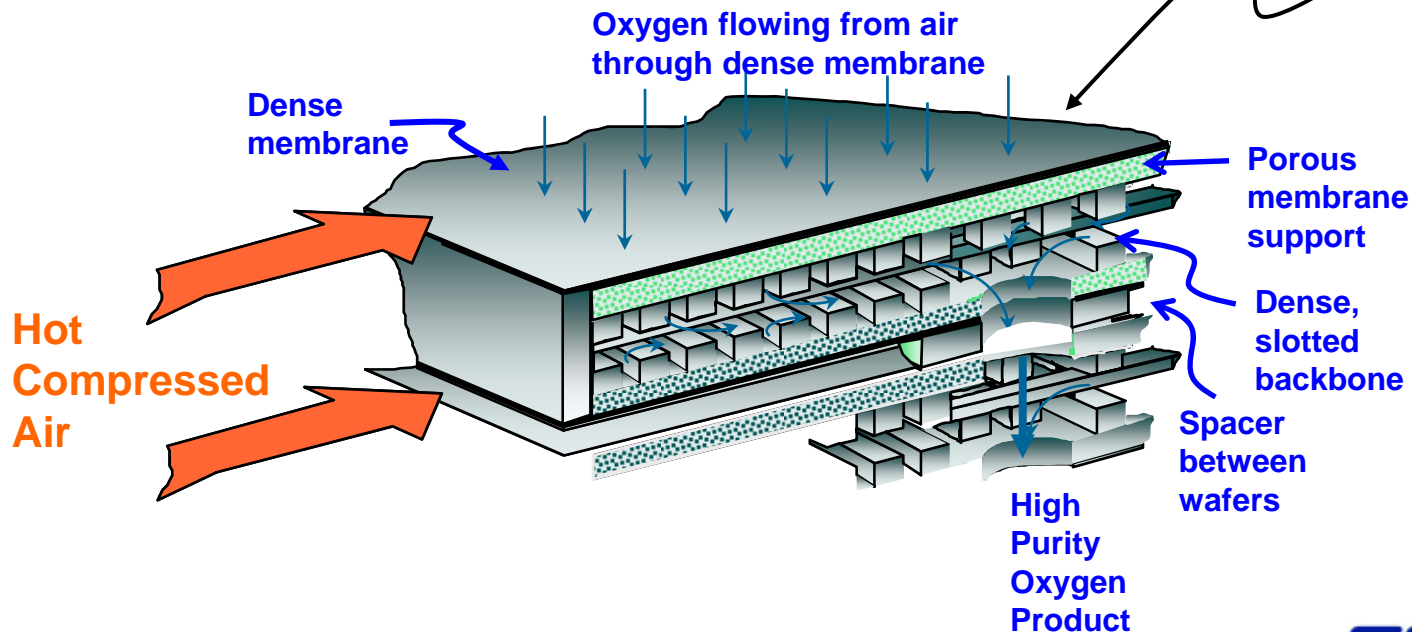
- **High-temperature process rather than cryogenic**
 - More efficient and lower capital cost heat exchangers
- **High-pressure rather than low-pressure separation**
 - Lower capital cost per plant size
- **Single-stage rather than multistage separation**
 - More efficient and lower capital cost
- **Compact design**
 - Easy to modularize, continued improvement in costs through scale-up
- **Technology at the beginning of its lifecycle**
 - Continued long-term efficiency and cost improvements



ITM Meets All These Goals

- **Oxygen Ion Transport Membranes**

- Operate at high temperature, typically greater than 700°C
- Oxygen is removed from high-pressure air
- Single-stage high purity oxygen
- Non-porous ceramic membranes
- Extremely selective and very fast transport for oxygen, very compact



One Membrane in Module

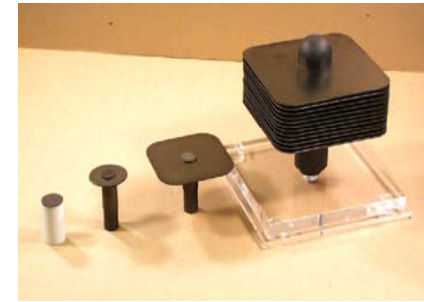


ITM Development Progression

Phase I. Developed and demonstrated materials and wafer architecture.

Phase II. Developed ceramic joining technology; built and tested commercial-scale ceramic modules in a 5-TPD pilot plant.

Phase III. Pilot work focused on scale-up and ceramic reliability; will build and operate a 150-TPD membrane system integrated with turbo machinery.



ITM Development Test – Ready to Go

- **DOE contract with Air Products in place** for construction and testing of turbomachinery-integrated 150 tpd-O₂ unit
- **Legal agreements** between EPRI and Air Products in process and working relationships largely in place
- **Scheduled activities in 2008**
 - Final host site selection
 - Design the ITM unit and testing program
 - Expand ceramic wafer manufacturing capability
 - Continue critical component performance testing (e.g., ceramic module)



Technical Objectives for Phase 3

Establish Performance of Integrated System

- Automate ceramic manufacturing techniques
- Scale-up membrane vessel
- Develop controls for turbomachinery integration
- Co-produce 5-15 MWe and 100+ tpd oxygen
- Provide critical scale-up data for larger power plants



ITM Development Test – EPRI Involvement

- **Ensure inclusion** of industry-relevant design features and tests in 150 tpd unit technology validation program
- **Evaluate** 150 tpd unit test progress and achievements
- **Provide power industry guidance** for formulating next-step development activities (to accelerate commercialization of ITM units meeting industry needs)
- **Manage** the EPRI collaborative's involvement in the 150 tpd development test program



Together...Shaping the Future of Electricity



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Image courtesy of NASA Visible Earth