FY 2008 Benefits Analysis for EERE's RD3 Portfolio

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Overview

- **The Baseline Case—the world without EERE**
- **The Portfolio Case—the world with EERE**
- **EERE Benefits Projections**

The EERE Portfolio is extremely diverse

- Hydrogen, Fuel Cells, and Infrastructure Program
- Biomass Technologies Program
- Solar Energy Technologies Program
- Wind Technologies Program
- Vehicle Technologies Program
- Building Technologies Program
- Industrial Technologies Program
- Federal Energy Management Program
- Weatherization and Intergovernmental Programs

The Baseline Case
The world without EERE

- **Adjustments are made to the official AEO 2006 reference oil price case**
- **Four types of changes**
  1. Removal of any EERE program effects
  2. Adjustment for greater or less technology improvement in the baseline than represented by AEO reference case
  3. Energy market updates
  4. Structural changes
- **More aggressive technological improvement in the baseline generally reduces the net impact of the EERE programs.**

The Baseline Case
Removal of EERE Program Effects

Program	AEO 2006	GPRA08
Building Technologies	Small penetration of highest efficiency shell packages	No penetration of highest efficiency shell packages
Biomass Technologies	Commercial cellulose ethanol technology available in 2015	Technology improves, but not commercially available until 2030

The Baseline Case
Greater Technology Improvements in Base

Program	AEO 2006	GPRA08
Solar Technologies	• Some improvement in photovoltaic system costs	• Slightly more improvement for commercial systems after 2020
Buildings Technologies	• Small improvement in solid state lighting	• Much greater improvement
Wind Technologies	• Onshore wind Performance: 35 to 44 percent capacity factors depending on wind class and year (2010 to 2030) • Onshore Wind Capital Costs: 0.3 percent reduction from 2010 to 2030	• 40 to 49 percent capacity factors depending on wind class and year (2010 to 2030) • 6 to 8 percent reduction (depending on wind class) from 2010 to 2030
Biomass Technologies	• Corn ethanol: Constant cost (excluding fuel and feedstocks) • Cellulose ethanol: Constant costs (excluding feedstocks)	• Improving costs over time, based on 7 year lag from Program goals • Improving costs over time, based on 15 year lag from Program goals
Vehicle Technologies	• Hybrid Electric Vehicles stock share 6% by 2030	• Hybrid Electric Vehicles stock share 11% by 2030

The Baseline Case
Energy Market Updates

Program	AEO 2006	GPRA08
Solar Technologies	• PV system size: 2 to 4 kW residential, 25 to 45 kW commercial • PV maximum market share: 30 percent for both residential and commercial • California PV subsidy: Not included	• PV system size: 4 kW residential, 100 to 200 kW commercial • PV maximum market share: 60 percent for residential and 55 percent for commercial • California PV subsidy: Included for residential systems
Biomass Technologies	• Cellulosic biomass supply curves use 1998 data • Cellulosic ethanol production is constrained to 50 to 280 million gallons per year	• Cellulosic biomass supply curves updated using 2006 data from UT • Cellulosic ethanol production can grow at 200 million gallons per year in first year and then at 500 million gallons per year or 20 to 25% of previous year (which ever is greater)

The Baseline Case Structural Changes

Program or Market Sector	AEO 2006	GPRA08
Wind Technologies	• Offshore wind capacity not included	• Offshore wind capacity included
Buildings (Distributed Generation)	• Non-Stock Accounting approach that applies an adoption rate to all existing buildings each year (max 0.5% annual adoption per year)	• Market share and stock accounting modified; growth rate imposed on solar PV installations
Vehicle Technologies	• Plug-In Hybrid Vehicles not included • Light Duty Vehicle attributes (makes, models) are held constant over time in NEMS.	• Plug-In Hybrid Vehicles included • Light Duty Vehicle attributes (makes, models) allowed to change over time to reflect evolving consumer preferences.

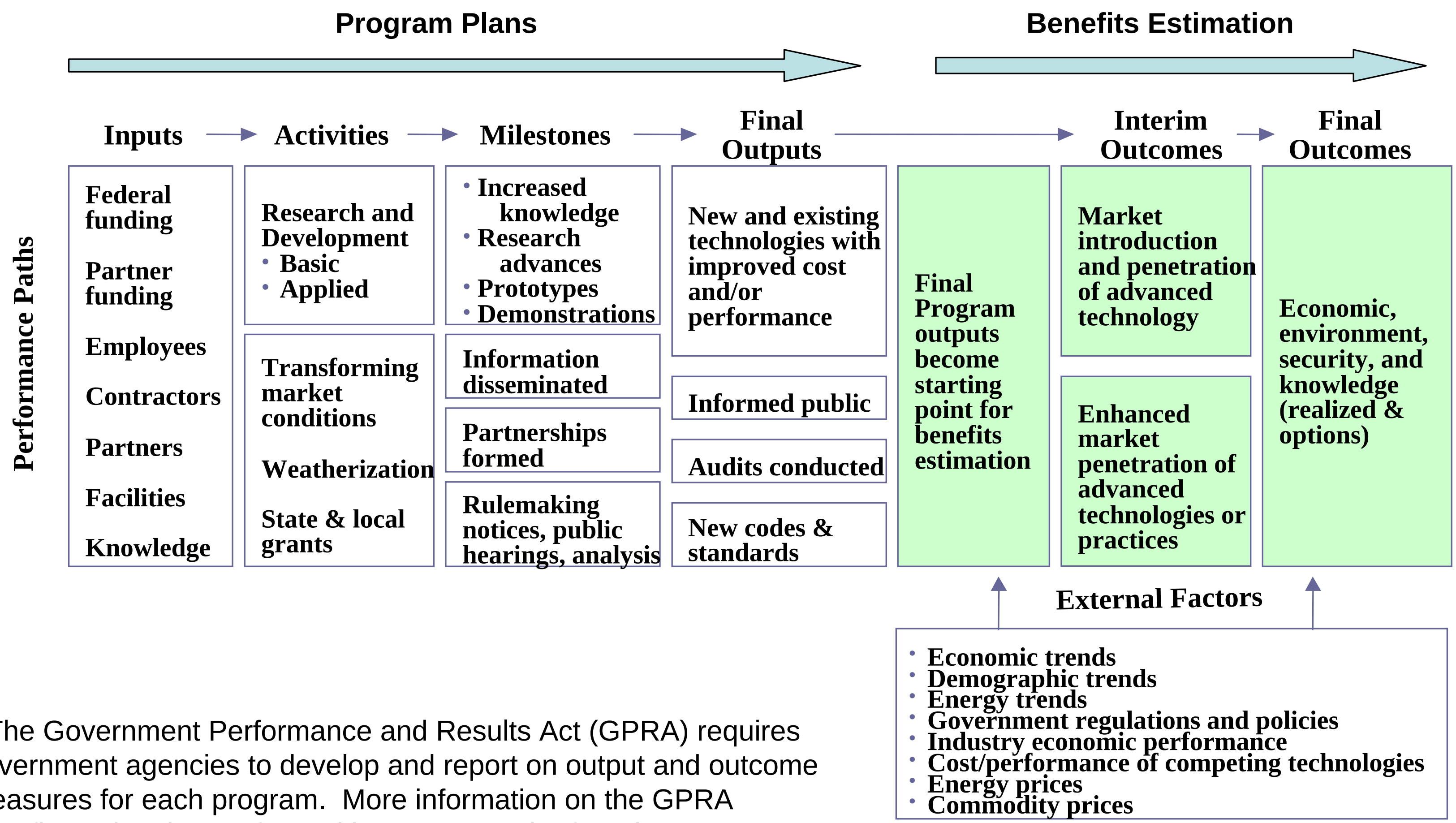
The EERE Portfolio Case

The Portfolio Case
The world with EERE

- Once the baseline has been established, each of the EERE programs' R&D and deployment goals ("outputs" in performance jargon) are reviewed.
- These goals are translated into inputs to the integrated energy models
  - Typically represented as projected technology cost and performance improvements
- The EERE portfolio cases (one for each scenario) include all of the programs' realized goals

EERE Program Planning and Benefit Estimation

- **The GPRA* process uses the outputs developed by the Program Offices to project technology adoption rates and resulting benefits.**



* The Government Performance and Results Act (GPRA) requires government agencies to develop and report on output and outcome measures for each program. More information on the GPRA benefits estimation performed by EERE can be found at:
http://www.eere.energy.gov/office_eere/gpra_estimates_fy06.html

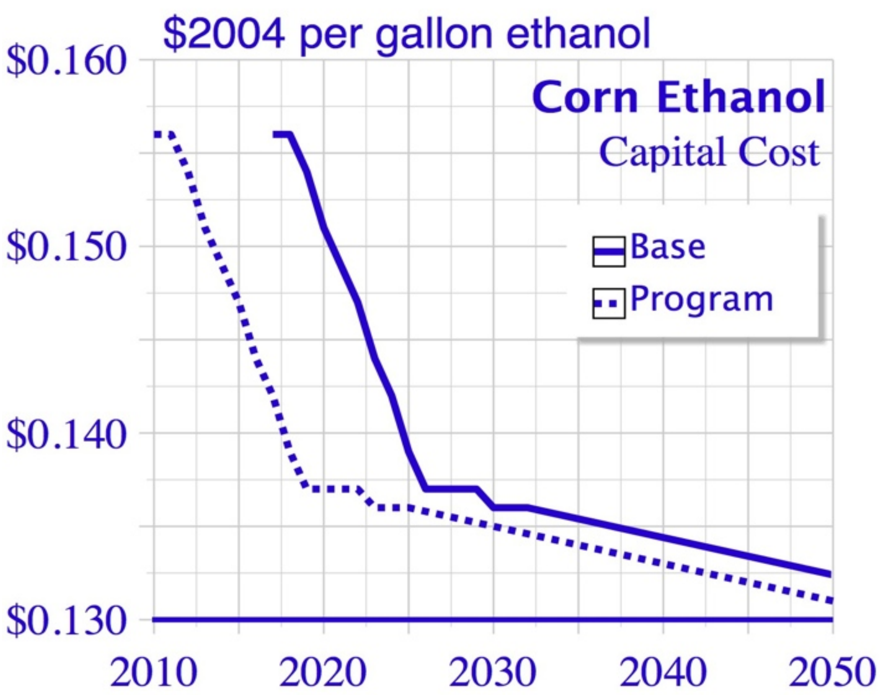
The Portfolio Case
Biomass Program Inputs

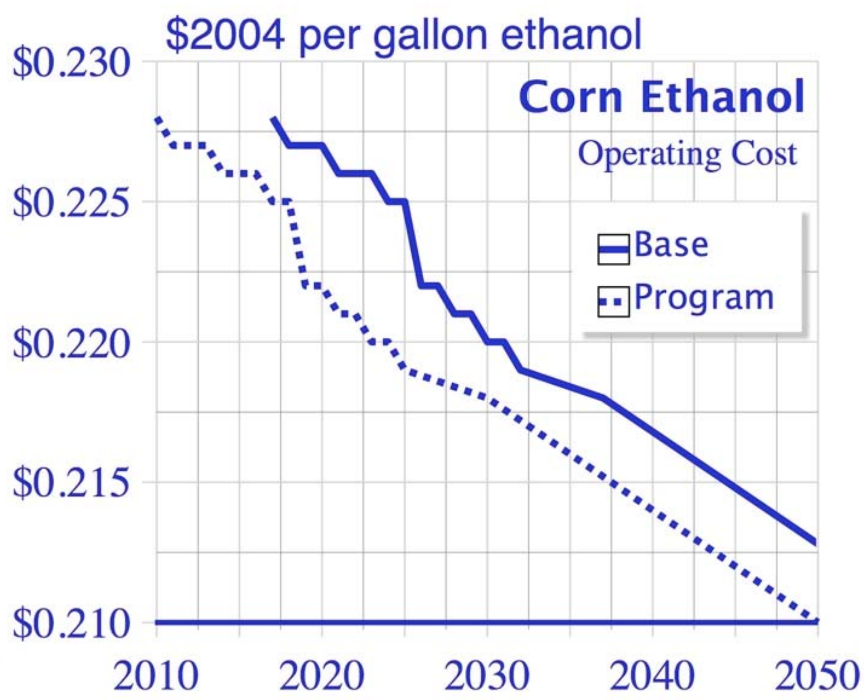
- **Key Program Outputs and Milestones**

Outputs	Key Milestones
• Enable first corn biorefinery with corn fiber and residual starch	• Conclude commercial demo with industry partner to increase ethanol output by at least 4% for each biorefinery by 2009
• Enable first pilot-scale project with corn stover	• Cost and performance evaluated at pilot scale against target selling price of $1.07 per gallon of ethanol with a $35/ton feedstock cost or $1.22 per gallon with a $45/ton feedstock cost by 2012
• Enable first demonstration-scale project with corn stover	• Deliver technology for stover collection and storage to demonstration scale project at costs of $35 to $45 per dry ton by 2013
• Enable switchgrass commercialization	• Increase switchgrass yield per acre by 10% at test sites by 2015 (from current regional levels) • Increase switchgrass yield per acre by an additional 5% at test sites by 2019 • Deliver technology for switchgrass collection and storage to demo-scale ethanol conversion project for $45 per ton by 2019
• Enable first pilot-scale project with switchgrass and residues	• Cost and performance evaluated at pilot scale against target yield of 90 gallons per ton by 2017
• Enable first demonstration-scale project with switchgrass or forest residues	• Cost and performance evaluated at demonstration-scale against target yield of 90 gallons per ton of feedstock by 2020
• Enable next-generation cellulosic biorefineries for ethanol production	• Deliver faster growing switchgrass and more competitive technologies for biomass production, collection, and storage to demonstration facilities • Industry partners construct, operate, and evaluate subsequent demonstration-scale projects

The Portfolio Case
Biomass Program Inputs

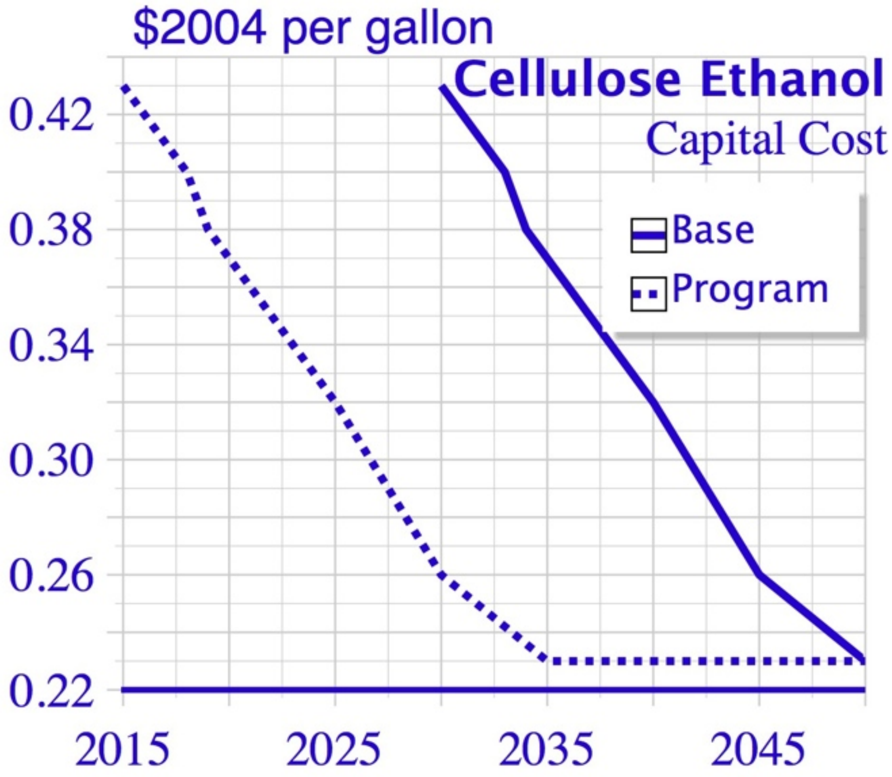
- 7-year lag between Program and Base Case

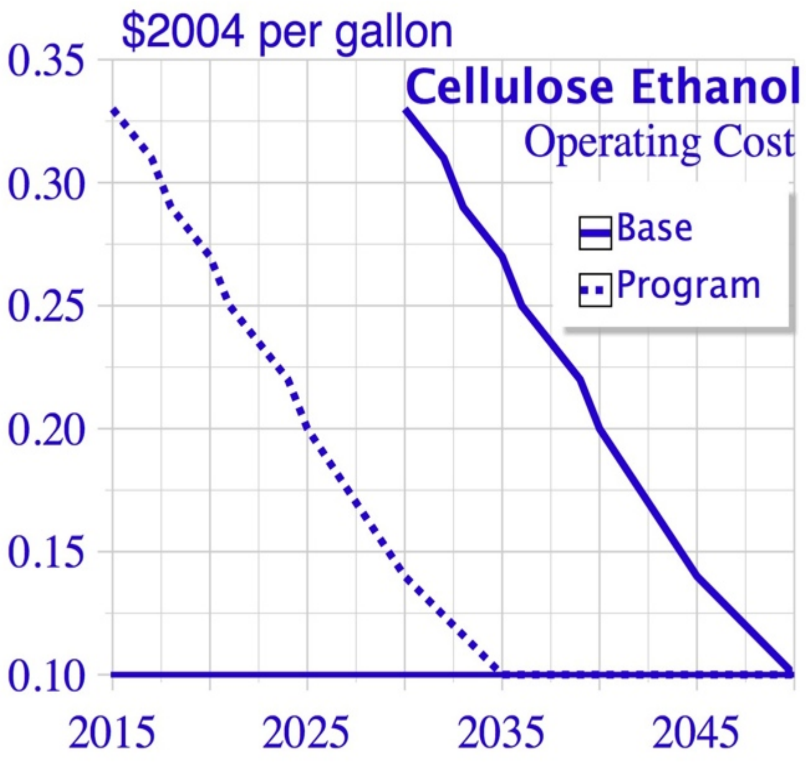




The Portfolio Case
Biomass Program Inputs

- **15-year lag between Program and Base Case**





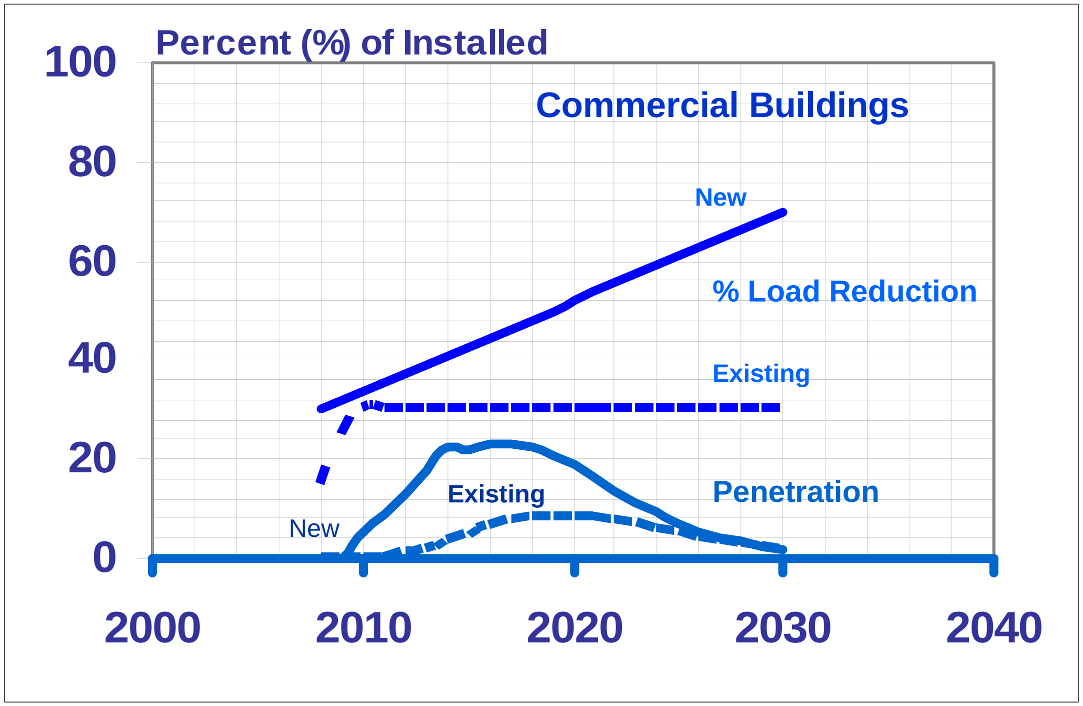
The Portfolio Case
Building Program Inputs

- Three broad strategies with many elements
  - Research and Development
    - Residential Buildings Integration (Building America)
    - Commercial Buildings Integration
    - Emerging Technologies
      - Lighting
      - Space Conditioning & Refrigeration
      - Building Envelope – Thermal Insulation & Materials
      - Building Envelope – Windows
      - Analysis Tools & Design Strategies
  - Equipment Standards and Analysis
  - Technology Validation and Market Introduction
    - Building Energy Codes
    - Energy Star
    - Rebuild America

- Many off-line analyses to translate program outputs into market outcomes

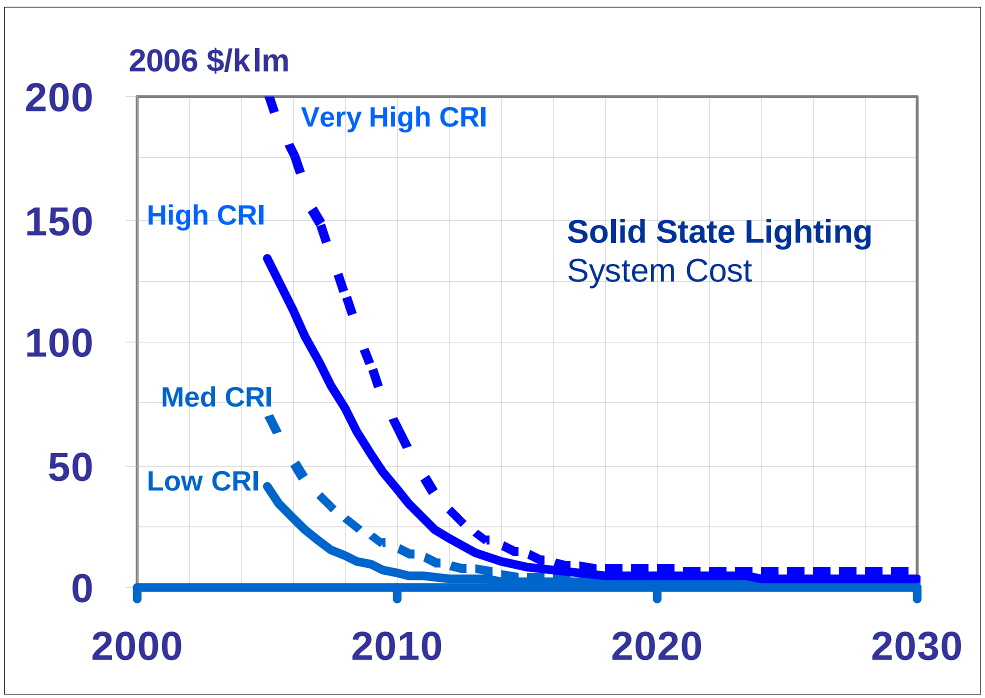
The Portfolio Case
Building Program Inputs – Commercial Buildings

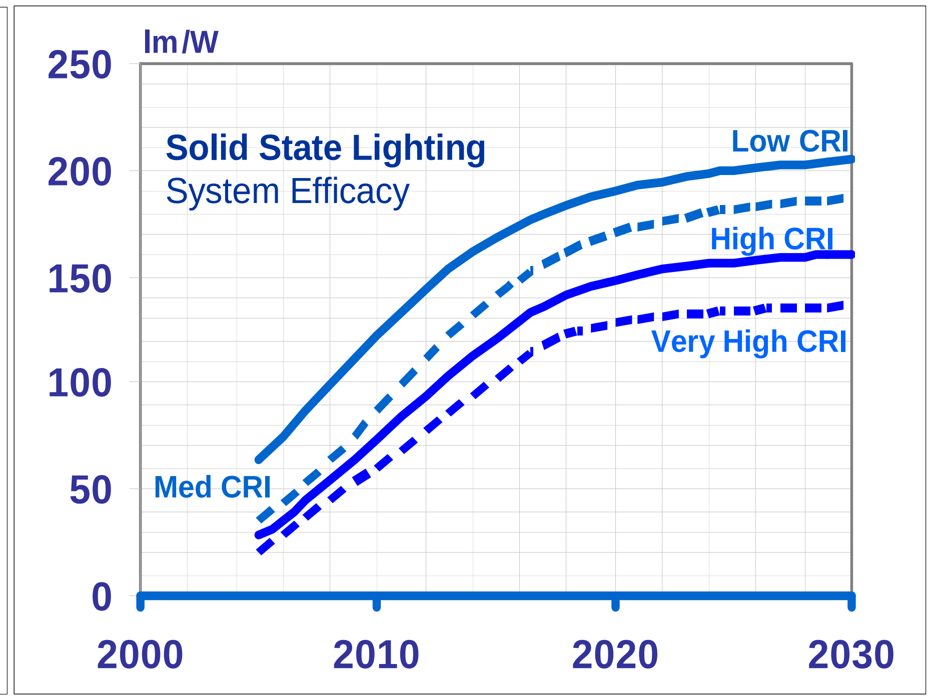
- **Goals achieved via:**
  - **Commercial Integration R&D,**
  - **Analysis Tools and Design Strategies that exceed ASHRAE 90.1-2004**
- **Penetration based on market diffusion curves developed by PNNL**
- **Assumes Program accelerates adoption of energy-savings products, technologies, and designs by 5 years**



The Portfolio Case
Building Program Inputs – Solid State Lighting

- Program is focused on lowering cost and improving efficacy
  - CRI = Color Rendering Index
- Introduction dates and expected efficacies based on:
  - *Solid-State Lighting Research and Development Portfolio* (Multi-Year Project Plan)
  - Navigant Consulting (2003) cost and performance study (included industry input)
- Energy Star branding assumed to impact penetration



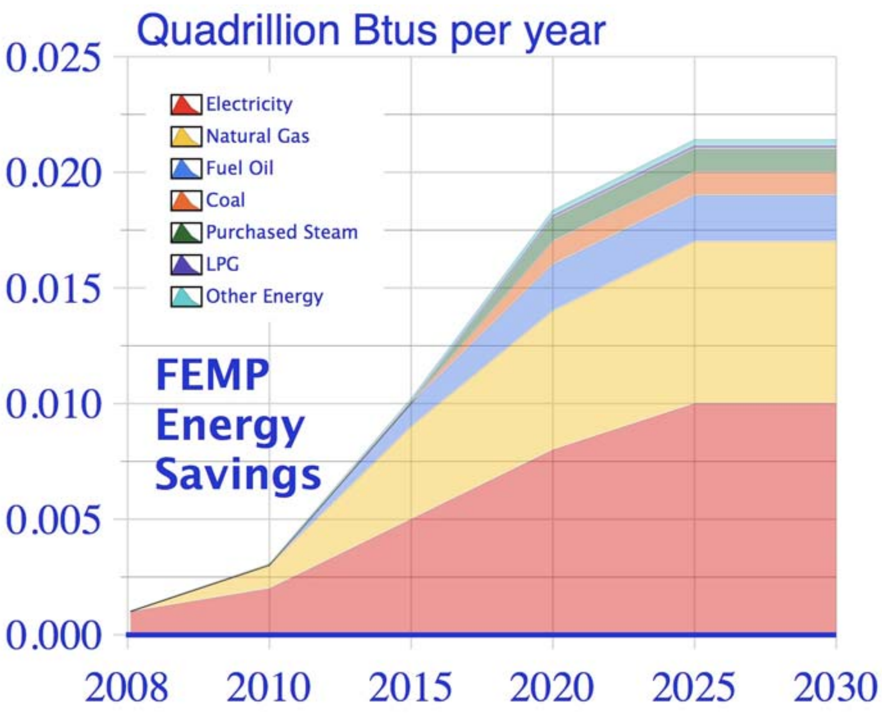


The Portfolio Case
FEMP Program Inputs

- **Key Program Outputs and Milestones**

Outputs	Associated Activities	Associated Milestones
Project Financing Activities (Annual)	Key activities 1. Energy Savings Performance Contracts (ESPC) 2. Utility Energy Savings Contracts (UESC) 3. Energy Markets/Shared Energy Savings Support	• Complete project financing activities • 14.9 trillion Btu annual lifecycle savings
Technical Assistance Activities (Annual)	Key activities 1. Technical Assistance Projects (TA) 2. Renewable Energy Purchases	• Complete technical assistance activities • 4.7 trillion Btu annual lifecycle savings • Support 0.6 trillion Btu annual renewable energy purchases

- **Projected annual energy savings estimated offline**



The Portfolio Case
Hydrogen, Fuel Cells, and Infrastructure Program

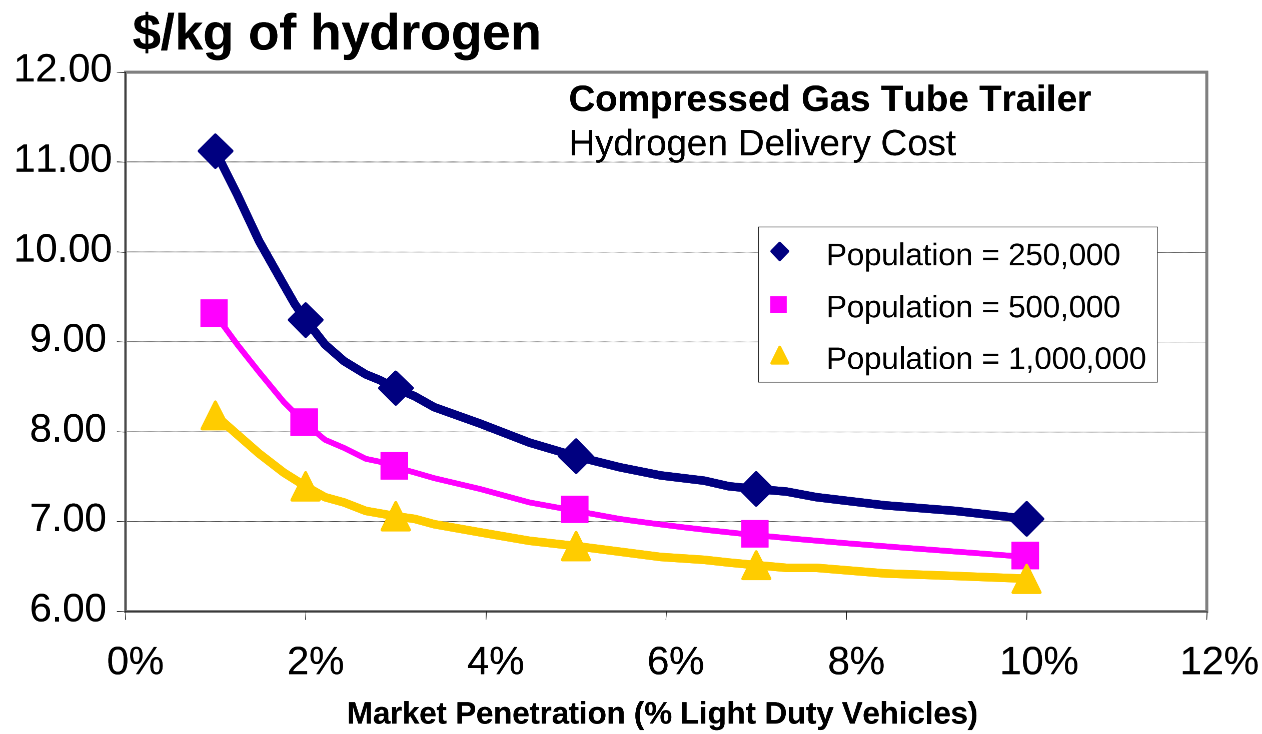
- **The HFCIT program is designed to validate 3 key technologies by 2015.**
  - **Hydrogen storage**
  - **Hydrogen production**
  - **Fuel cell engine costs**
- **Achieving the Program's Technology Readiness Milestones in 2015 will begin to yield national benefits by 2025**
- **Benefits were estimated with MARKAL only**
  - **Only long-term (2030-2050) benefits estimated**
  - **NEMS does not yet have a full representation of hydrogen supply**

The Portfolio Case
Hydrogen, Fuel Cells, and Infrastructure Program

- **Hydrogen Production**
  - Nine hydrogen production technologies modeled based on data availability and likelihood of success
  - Capital & O&M costs and production efficiencies estimated via
    - H2A production models (drawing from industry, academia, and national laboratory expertise)
      - Central coal and natural gas reformers
    - Program goals
      - Distributed natural gas reformers
      - Central biomass gasifiers
      - Central and distributed electrolytic production technologies

The Portfolio Case
Hydrogen, Fuel Cells, and Infrastructure Program

- Hydrogen Distribution
  - Distribution costs estimated by market size and market penetration for specific distribution methods
  - Costs decline to program goals in 2030 (large cities) and 2035 (medium cities)

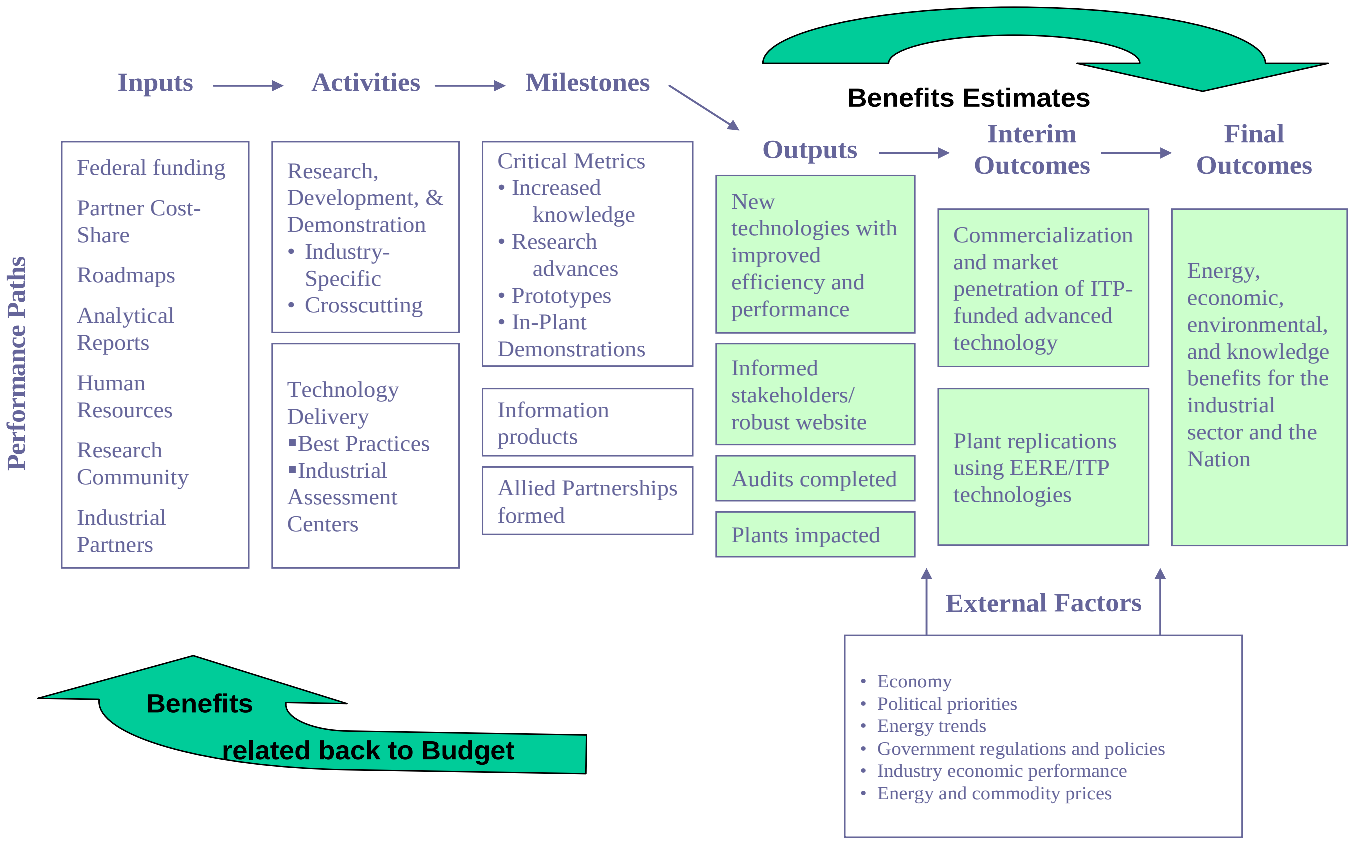


The Portfolio Case
Hydrogen, Fuel Cells, and Infrastructure Program

- **Fuel Cell Vehicle and Transportation**
  – Fuel Cell Vehicles compete with advanced conventional petroleum and hybrid vehicles in light duty and commercial light truck markets.
    - Assume success of Vehicle Program's hybrid systems and materials technologies R&D, but not as efficient
  – Fuel Cell Vehicle (car) fuel efficiency is expressed as a multiple of the efficiency of a conventional gasoline vehicle of the same year:
    - By 2020, 2.2 X as fuel efficient
    - By 2030, 2.4 X
    - By 2050, 2.8 X

The Portfolio Case
Industrial Program Inputs

ITP Logic Model

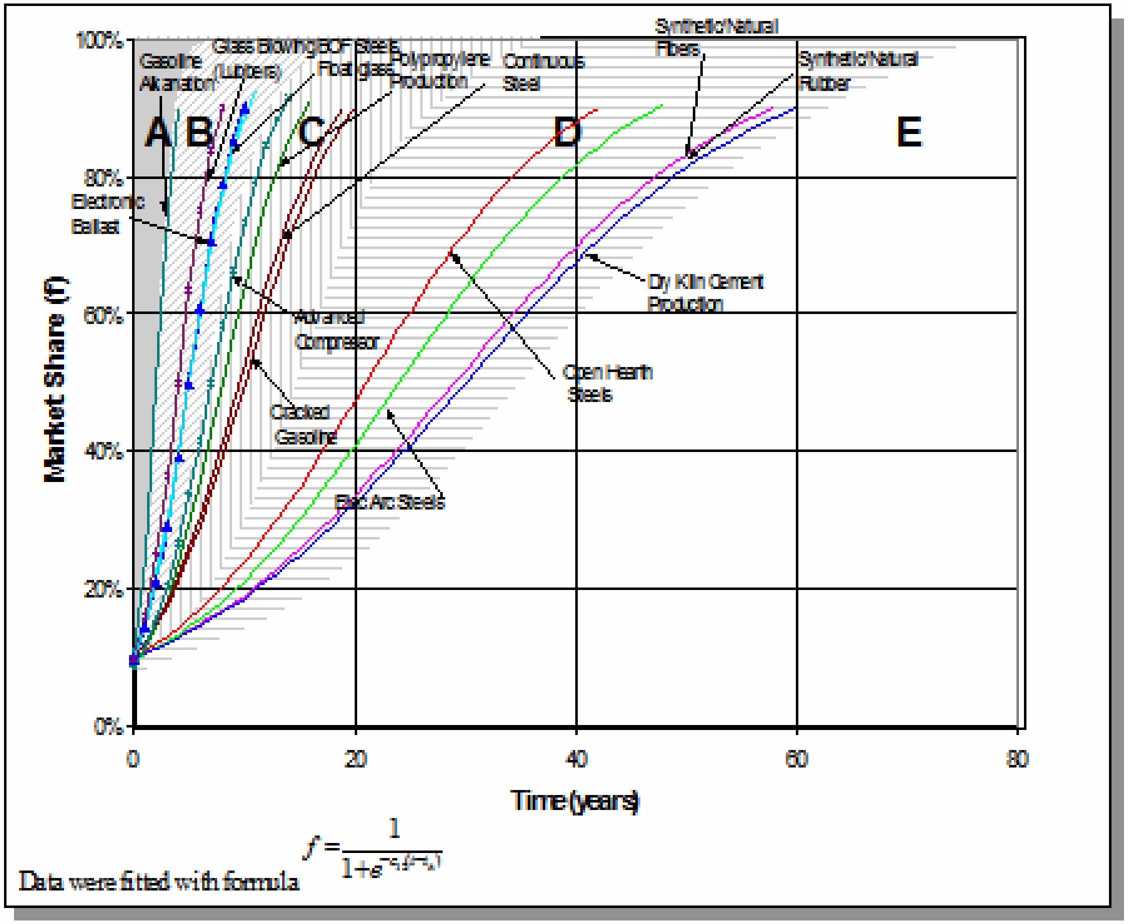


- **Benefits estimated for**
  - **RD&D Activities (Industry-specific and Cross-cutting technologies)**
  - **Technology Delivery Activities (Best practices and Industrial assessment)**

The Portfolio Case
Industrial Program Inputs

- **Off-line study estimates program outputs**
  - **55 advanced technologies ready for commercialization, most by 2011 (R&D)**
  - **Industrial Assessment Center energy assessments at 600 small and medium size plants per year**
  - **Energy savings assessments at 200 plants per year**
- **Market penetration of a new technology based on**
  - **Technology development and commercialization timeline**
  - **Identifying appropriate market penetration curve**

The Portfolio Case
Industrial Program Inputs



- Market penetration curves (by technology class)
  - Based on actual rates of past and present technologies
  - Class selection for a specific technology based on consideration of multiple characteristics and criteria including
    - Payback period
    - Scale
    - Equipment lifetime
    - Market growth rate

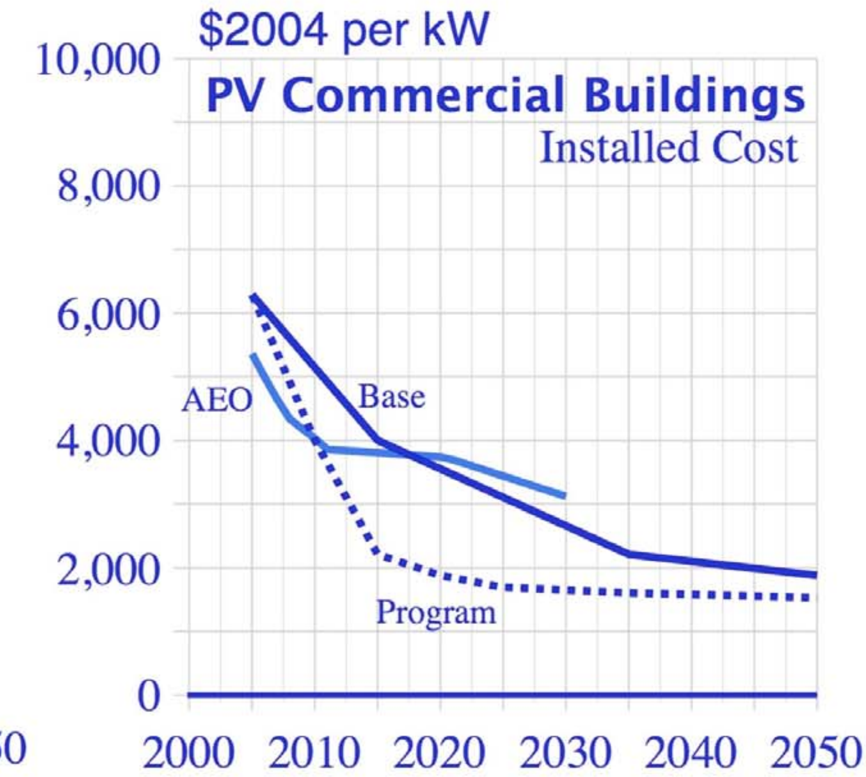
Time to Saturation (Years)				
A	B	C	D	E
5	10	20	40	>40

The Portfolio Case
Solar Program Inputs - PV

- **Program costs based on:**
  - **Multi-Year Project Plan (Pre-Solar America Initiative (SAI))**
  - **Internal analyses**
  - **US PV Industry Roadmap**
  - **Goals have been accelerated based on anticipated changes to structure and funding in FY07 under SAI**

The Portfolio Case
Solar Program Inputs - PV

- **5-year lag between Program and Base Cases until 2015; continued divergence thereafter**



The Portfolio Case
Solar Program Inputs - CSP

- CSP Program costs based on FY07 budget request and Draft CSP Technology Transition Plan
- Focused on CSP systems with larger storage capacity than in AEO and GPRA08 Base Case
- CSP Capacity factors optimize timing of solar output for each region within bounds of storage potential

The Portfolio Case
FreedomCar and Vehicle Program Inputs

Light Vehicle Methodology

- **Selection of vehicle types (e.g. conventional, hybrids, fuel cells) is based on consumer preferences for various attributes**
  - **Programs goals reflected in these attributes**
  - **Attributes expressed as ratios to conventional vehicles**
  - **Variations in vehicle cost and fuel efficiency are the most important**

NEMS	MARKAL
Vehicle Cost	Vehicle Cost
Fuel Efficiency	Fuel Efficiency
Fuel Price (internally derived)	Fuel Price (internally derived)
Maintenance Costs	Maintenance Costs
Vehicle Range	
Acceleration	
Luggage Space	
Fuel Availability	
Make and Model Availability	
12 classes (6 cars and 6 light trucks)	2 classes (1 car and 1 light trucks)

The Portfolio Case
FreedomCar and Vehicle Program Inputs

Supporting Offline Models

- **Payback:** **Estimates the incremental cost to the consumer that would be necessary to obtain a 3-year payback**

- **PSAT:** **Powertrain Systems Analysis Toolkit (developed by FCVT)**
  - **User Inputs for Vehicle: weight, frontal area, engine characteristics, driving cycle**
  - **Model Output: fuel efficiency, top speed, 0-60 times**

The Portfolio Case
FreedomCar and Vehicle Program Inputs

Heavy Vehicle Methodology

Assesses overall fuel economy effect of technology change – engine and other elements

HTEB
(Heavy Truck Energy Balance)

Estimates market penetration based on the cost-effectiveness of new technology

TRUCK 3.0
(Heavy Truck Market Penetration)

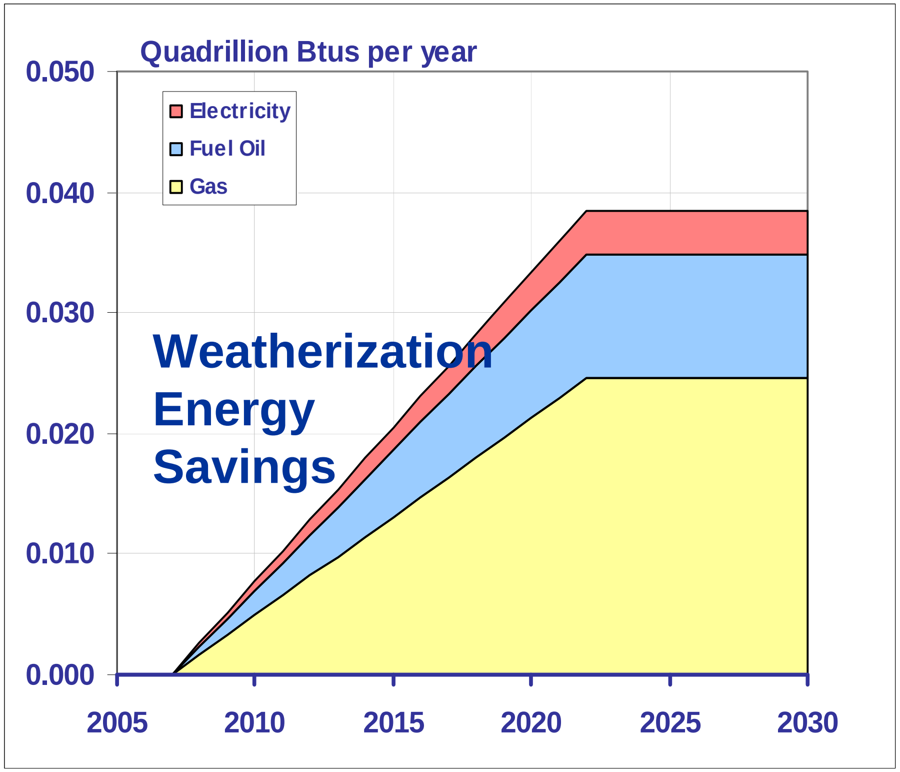
Penetration rates
Per truck savings

NEMS/
MARKAL

Estimates energy savings and benefits

The Portfolio Case
WIP Program Inputs

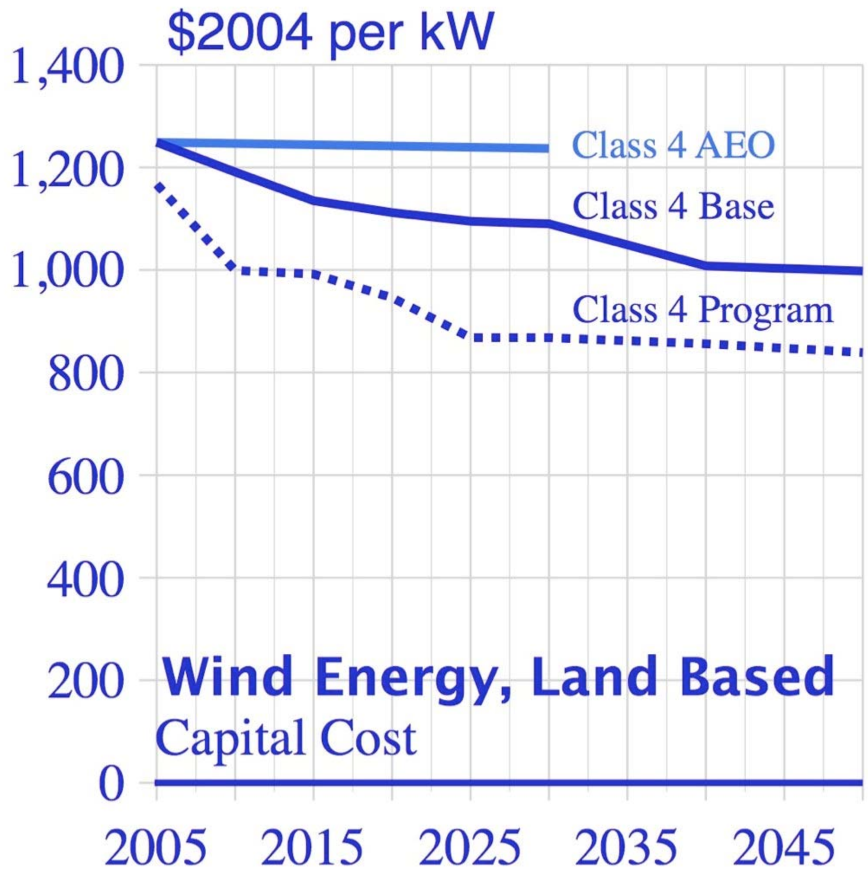
- **Projected annual energy savings estimated offline**
- **Two sub-programs evaluated**
  - **Weatherization Assistance**
  - **Tribal Energy**
  - **State Energy Program (SEP) not included**
- **Weatherization energy savings based on**
  - **Leveraged funds**
  - **Estimated level of savings per household (regional)**
  - **Cost to weatherize each household (regional)**
  - **Regional distribution of households**
  - **Assumed life expectancy of 15 years for weatherization measures**

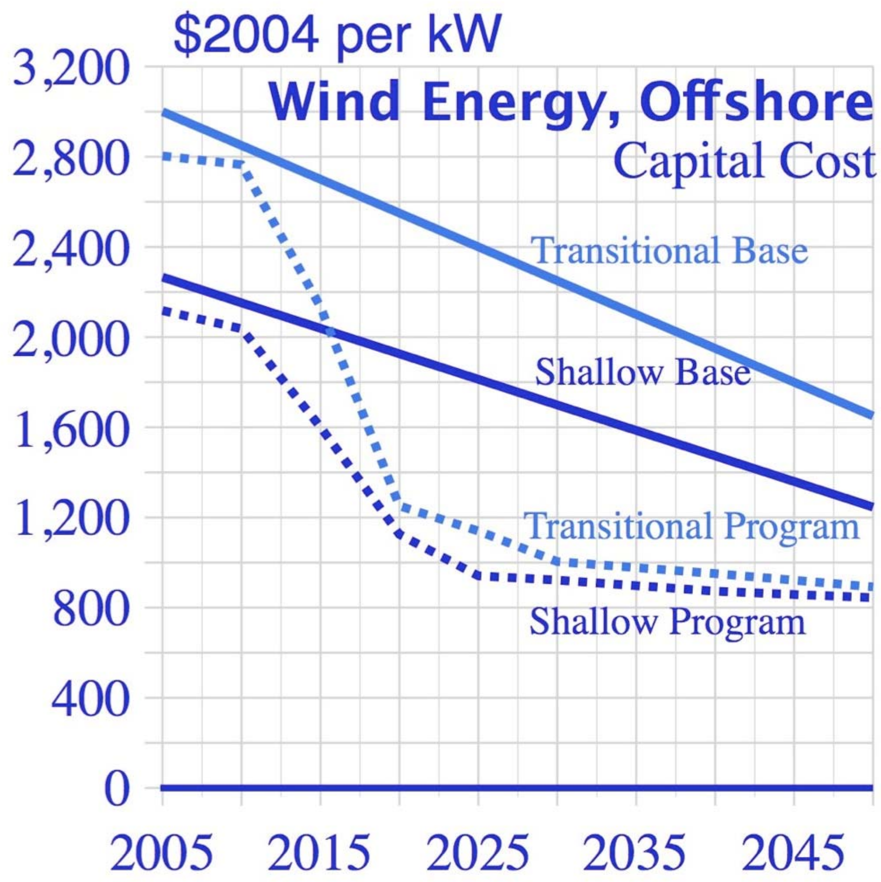


The Portfolio Case
Wind Program Inputs

- **Focused on Low Wind Speed Technology, for both land-based and offshore turbines**
- **Program costs are based on:**
  - ***Low Wind Speed Technology Pathways Analysis Methodology and Baseline* (NREL, 2006)**
- **If EERE decides to pursue offshore R&D in 2009, will begin to fund R&D in shallow and transitional depths.**

The Portfolio Case
Wind Program Inputs





EERE Benefits Estimates

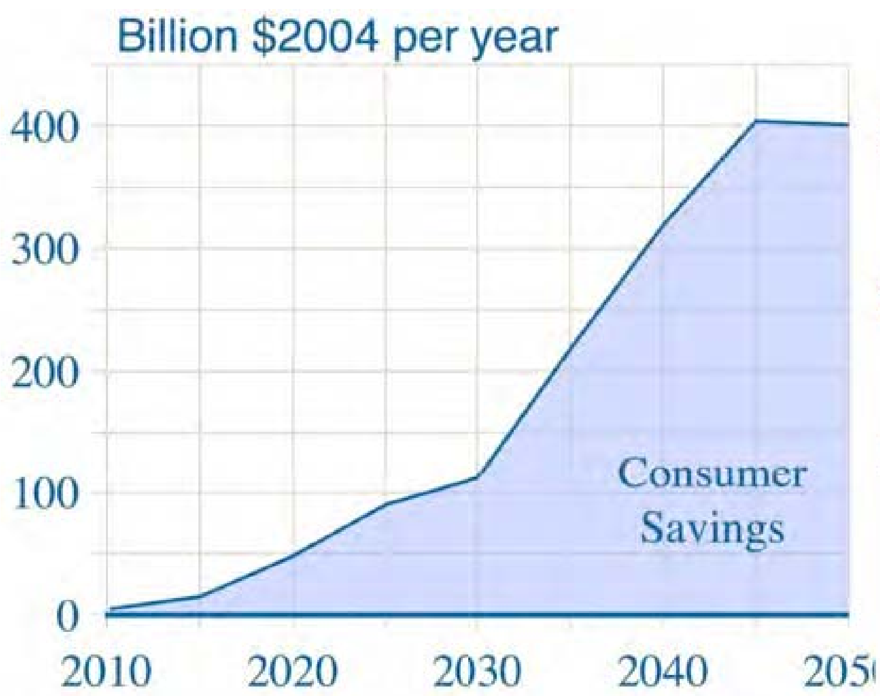
Representative Results

- **One showing “Business As Usual” (BAU) results through 2050**
  - **NEMS-GPRA08 used for 2010 - 2030**
  - **MARKAL-GPRA08 used for 2030 – 2050**

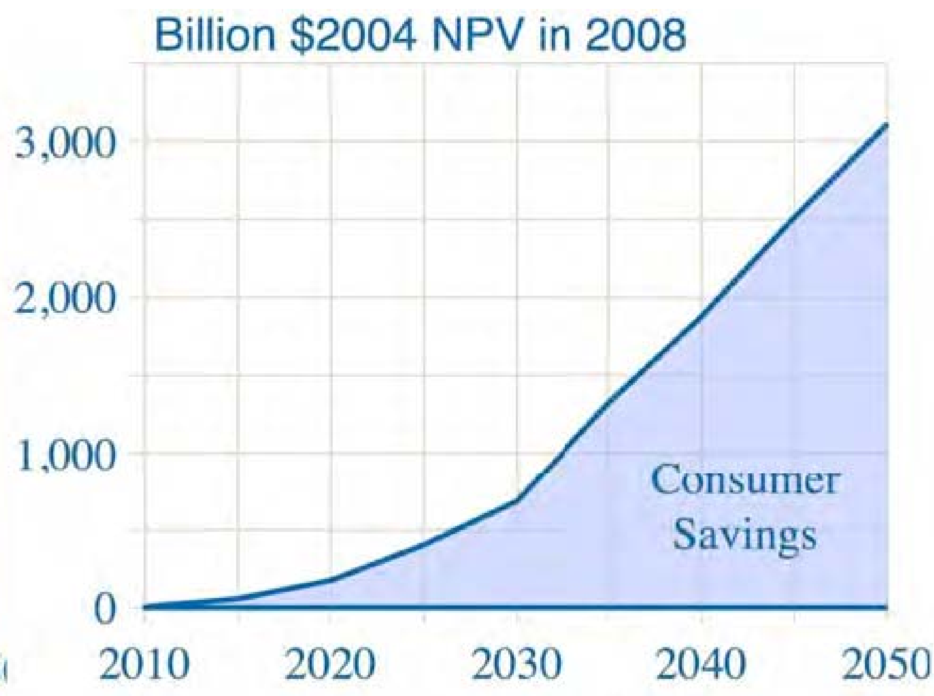
- **Several showing BAU, High Fuel Price (HFP), and Carbon Constraint (CC) scenario results**
  - **Results currently limited to NEMS-GPRA08 so scenario estimates end at 2030.**

Economic Benefits
Consumer Savings (BAU Only)

Billion ($2004) per year

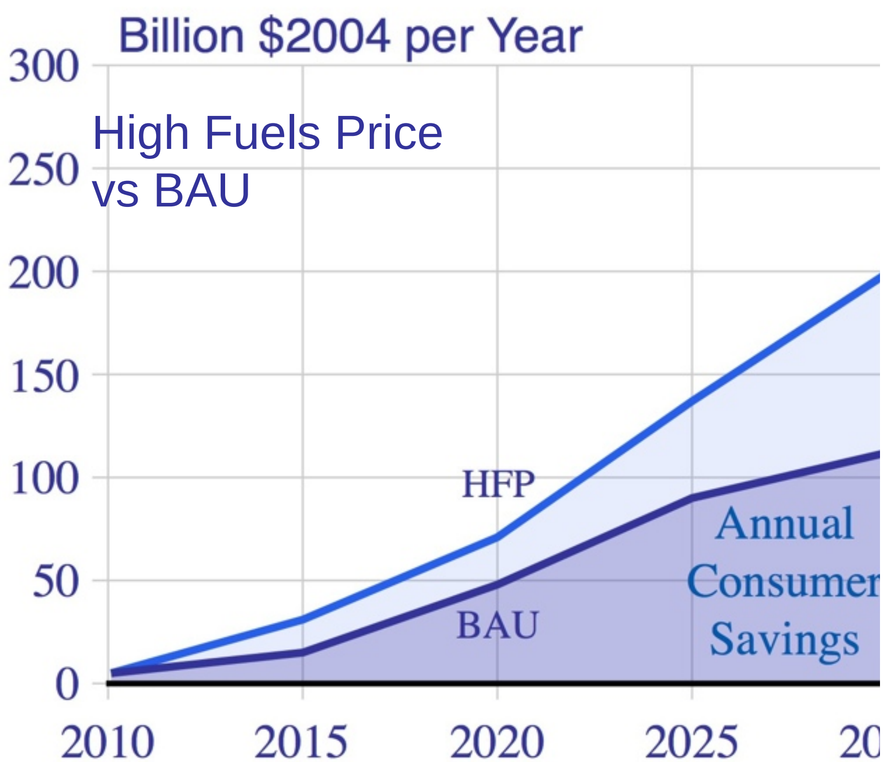


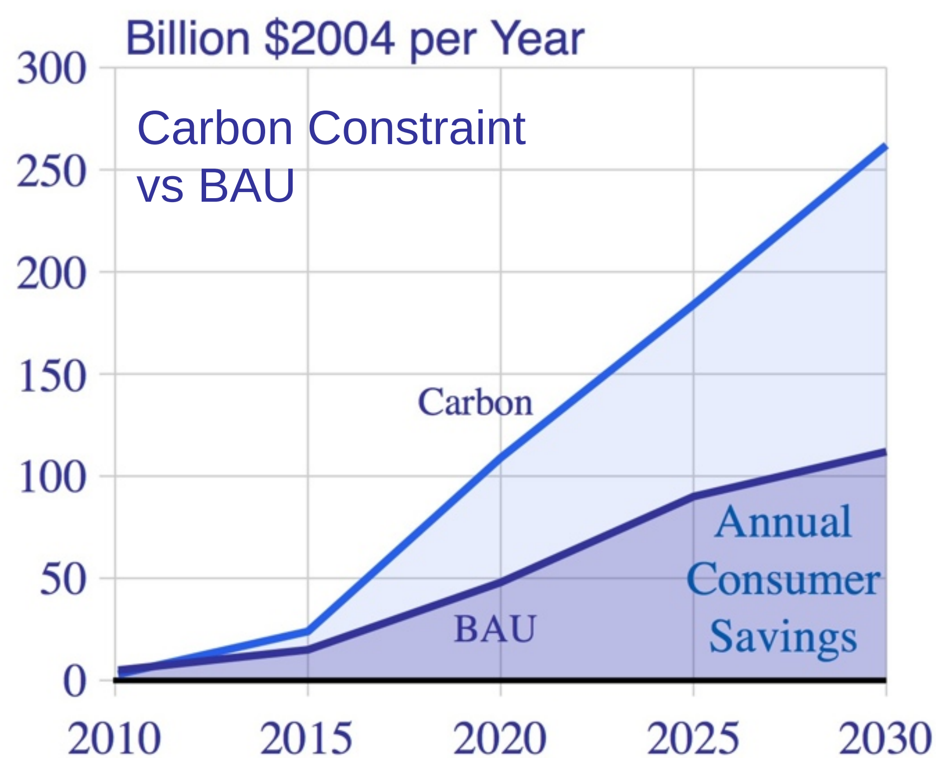
Billion ($2004), Cumulative at 3% real discount rate



Economic Benefits
Consumer Savings

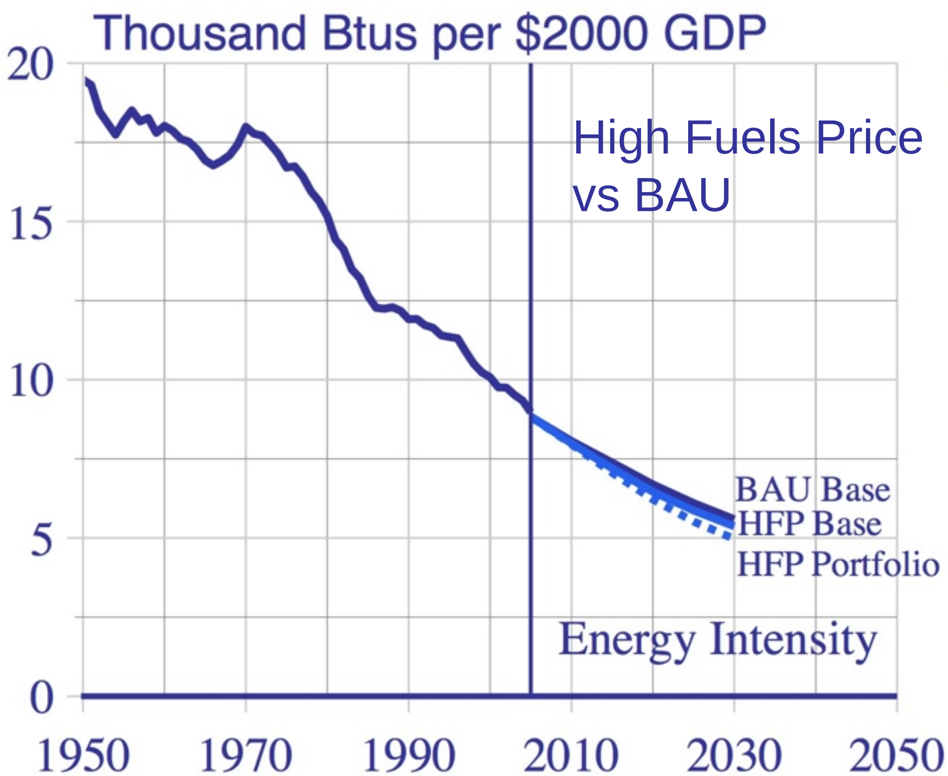
- **Greater impacts under High Fuel Price and Carbon scenarios**

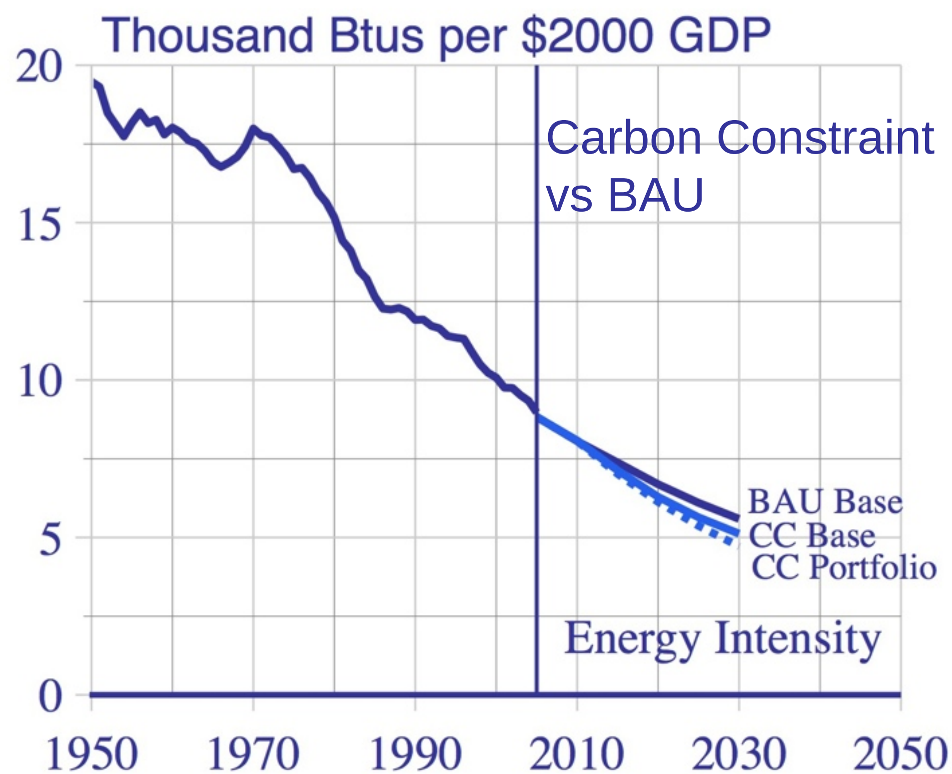




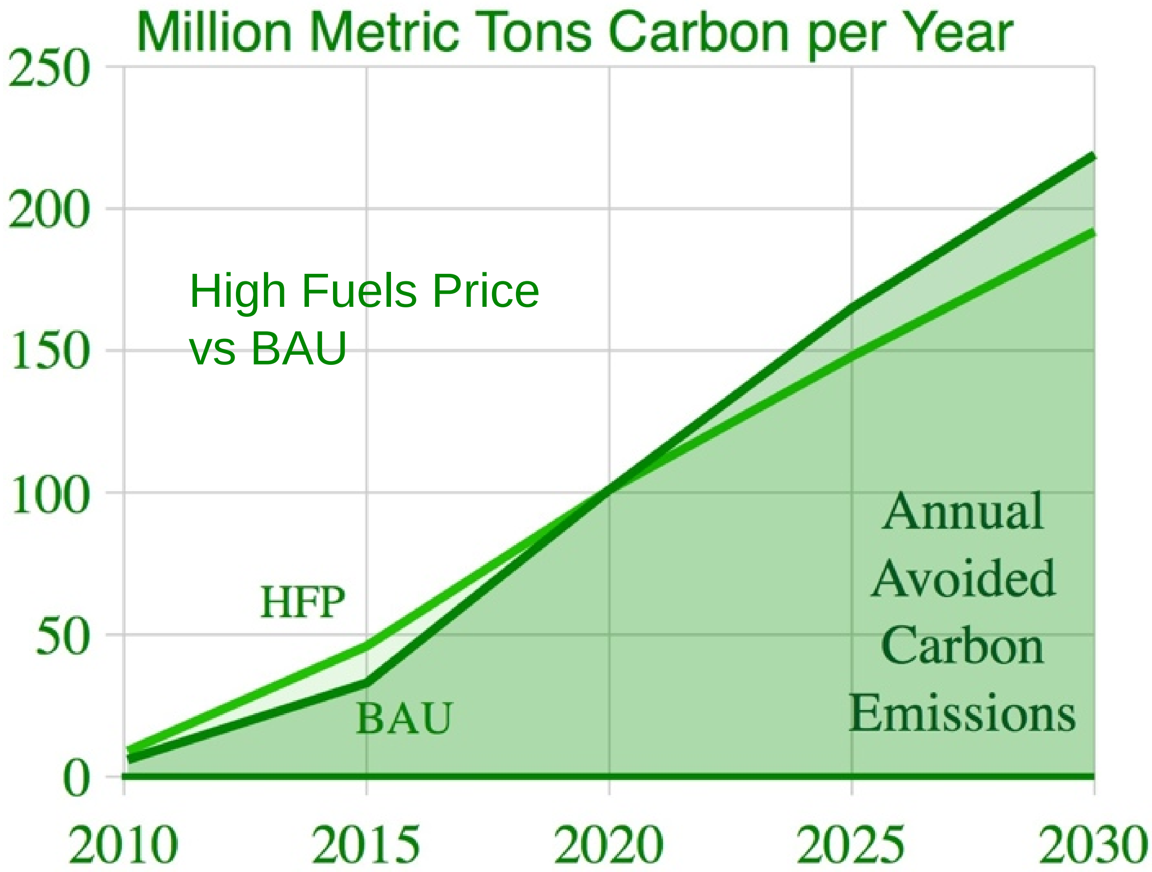
Economic Benefits
Energy Intensity of the Economy

- 7 to 8% reductions in energy intensity for all scenarios in 2030





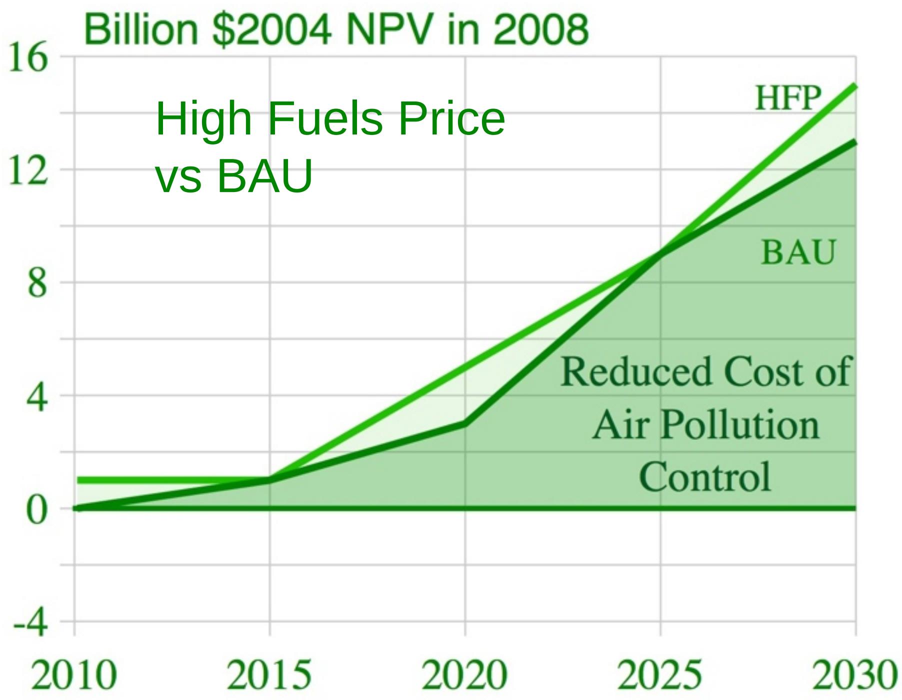
Environmental Benefits
Annual GHG Emissions

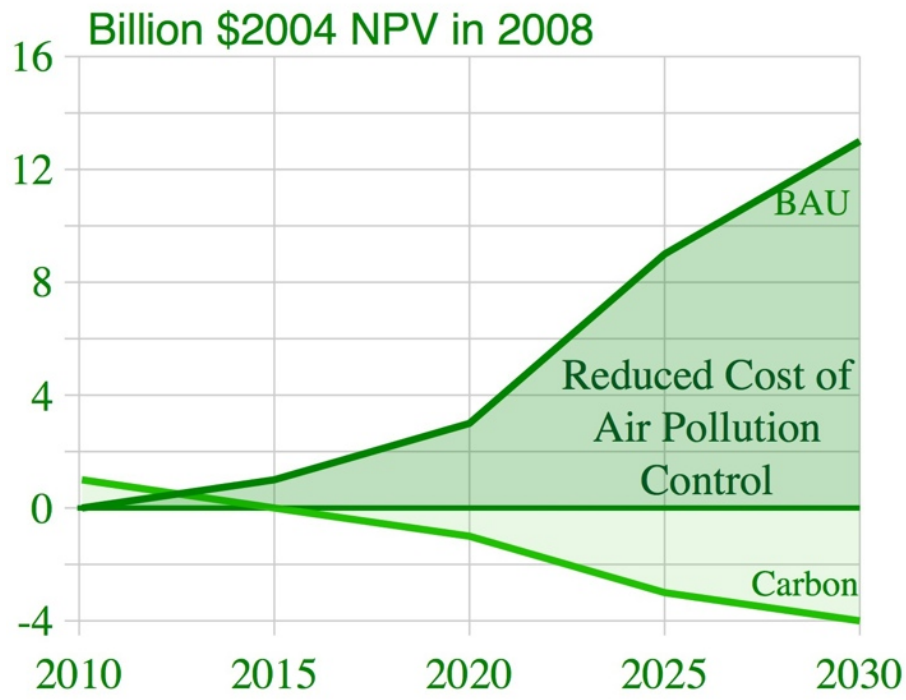


- 180 to 220 million metric tons of carbon equivalent savings in 2030 under the Business-as-Usual and High Fuel Price Scenarios

Environmental Benefits
Air Pollution Control Costs

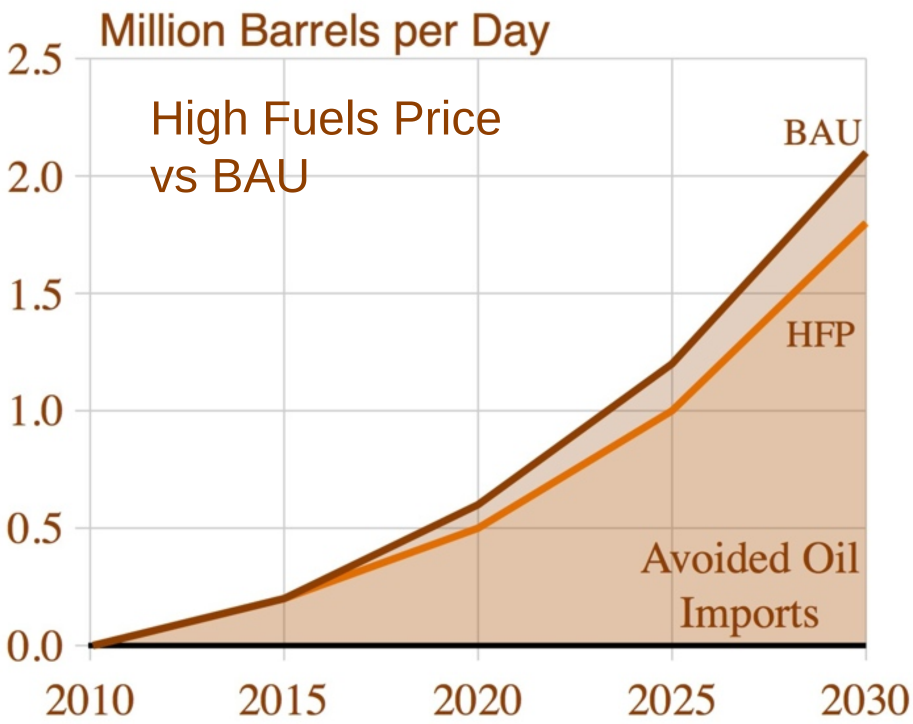
- **$13 to 15 billion savings under the BAU & HFP; Higher cost under the carbon scenario in 2030**

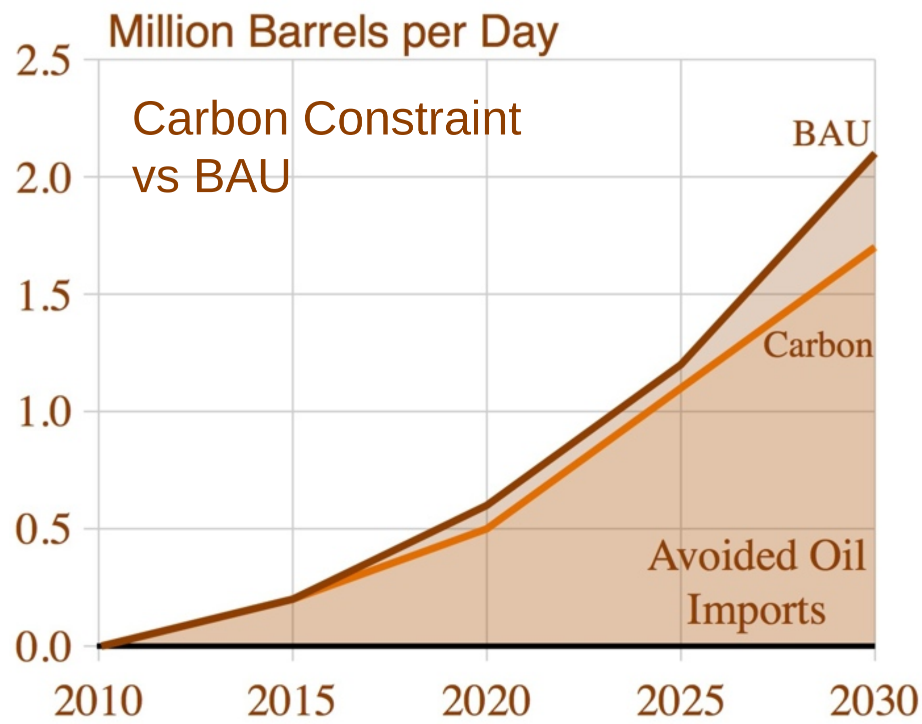




Security Benefits
Avoided Oil Imports

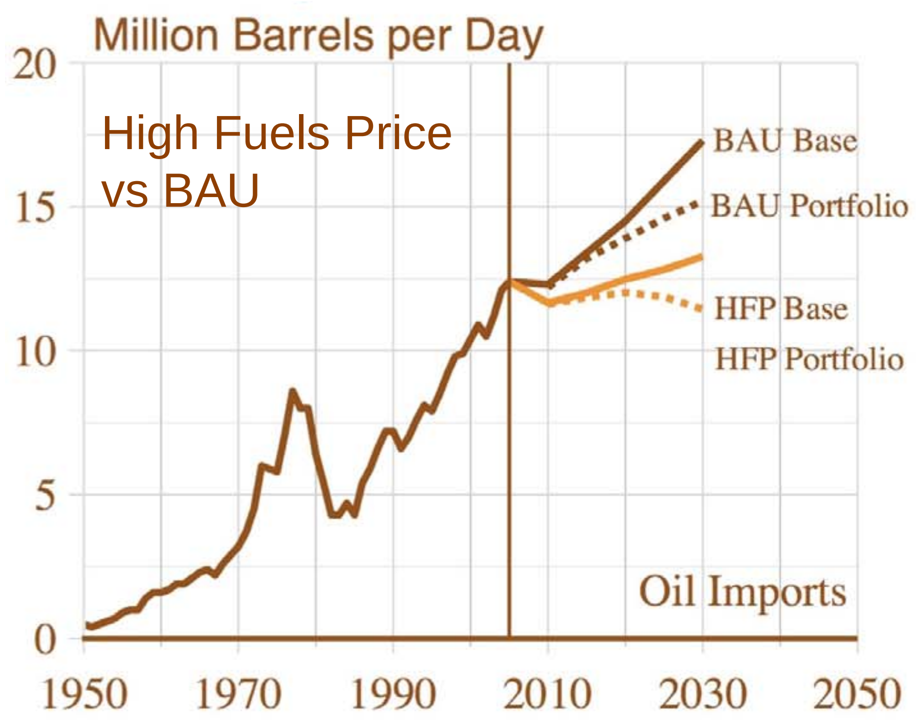
- ~2 million barrels per day avoided oil imports under all scenarios

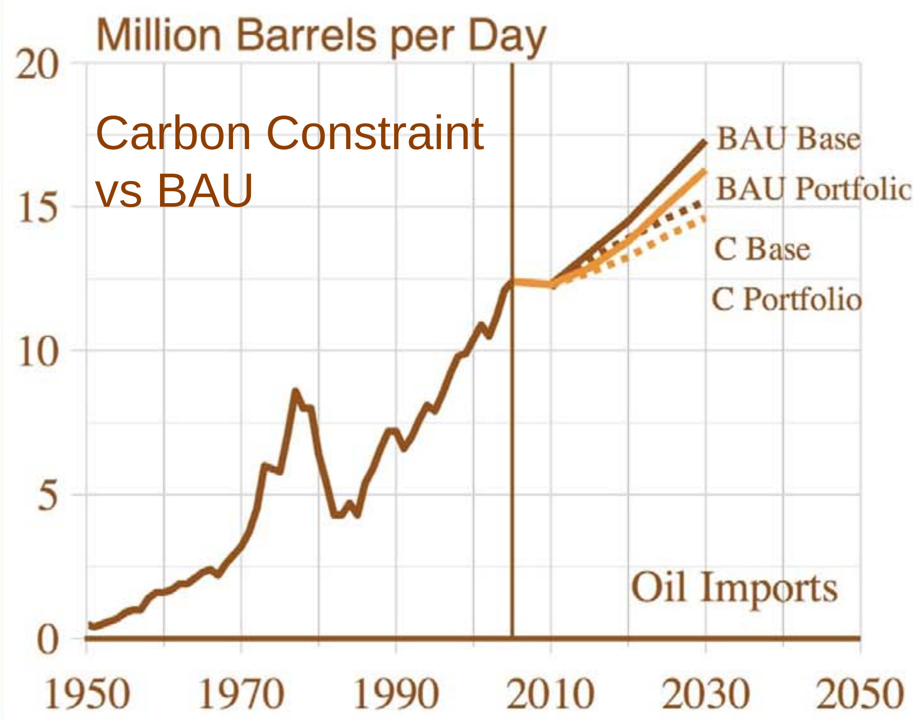




Security Benefits
Oil Imports

- **Absolute oil imports avoided are substantial for the high fuel price, carbon constraint scenarios**





Backup/Context

Guidance Elements

- **Documentation - Document, provide sources, and justify all sources**
- **Linkage to Program Planning - Align GPRA targets, milestones, and outputs with programmatic vision and budget planning**
- **DOE Program Impact v. Baseline Technological Progress - Provide a fully documented and data-driven intuitive "storyline" for any forecast of technological change**
- **"Offline" Analyses Conformance – Analyses used to construct inputs should conform and accord with the assumptions underlying and the results generated "endogenously" by the integrated models**
- **Calculation Rules and Assumptions – Provide clear calculation rules and assumptions that underlie the inputs**

Charge Questions

- Does the documentation clearly describe the basis for benefits forecasts so that all assumptions and calculations are understood?

- Are the assumptions associated with the benefits forecast plausible or believable?
  - Are assumptions data driven?
  - Are sources cited?
  - Is there clear linkage between R&D budgets and assumptions?

- Was the methodological guidance for benefits forecasts followed?

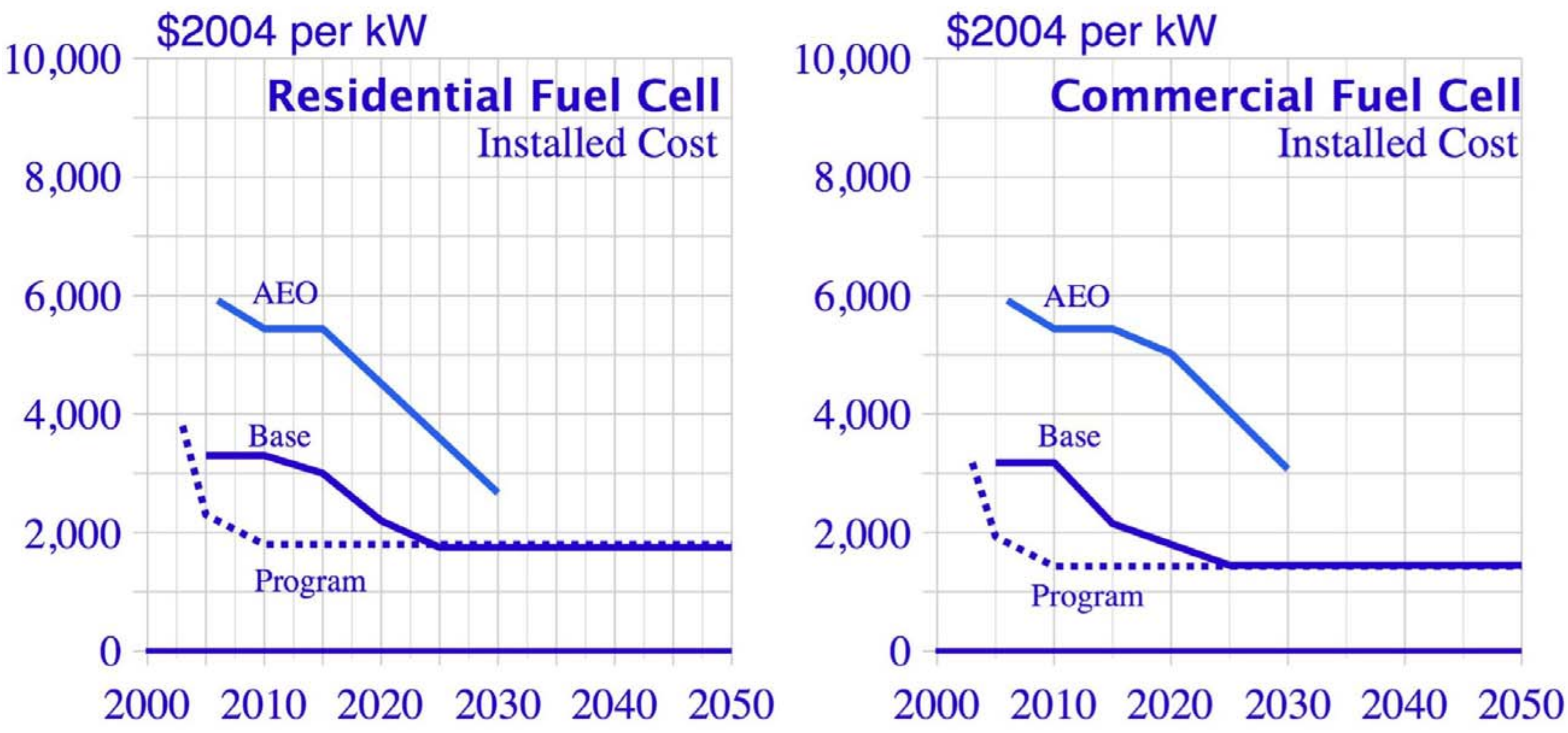
- Is the baseline used an appropriate representation of the future without federal funding?

- Are the DOE program goals used in the benefits forecast appropriately represented in NEMS, MARKAL, and any additional calculation tools used?

The Portfolio Case
Hydrogen, Fuel Cells, and Infrastructure Program

Stationary Applications

- **Baseline and program cases use costs and efficiencies for current technology based on recent program status review**



Security Benefits
Oil Intensity of the Economy

- **8 to 9% decrease in oil intensity under all scenarios**