Integrated Resource Planning

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Purpose of IRP

- To meet demand for energy services at the **least cost to society**, including environmental costs

Least-Cost Integrated Resource Planning

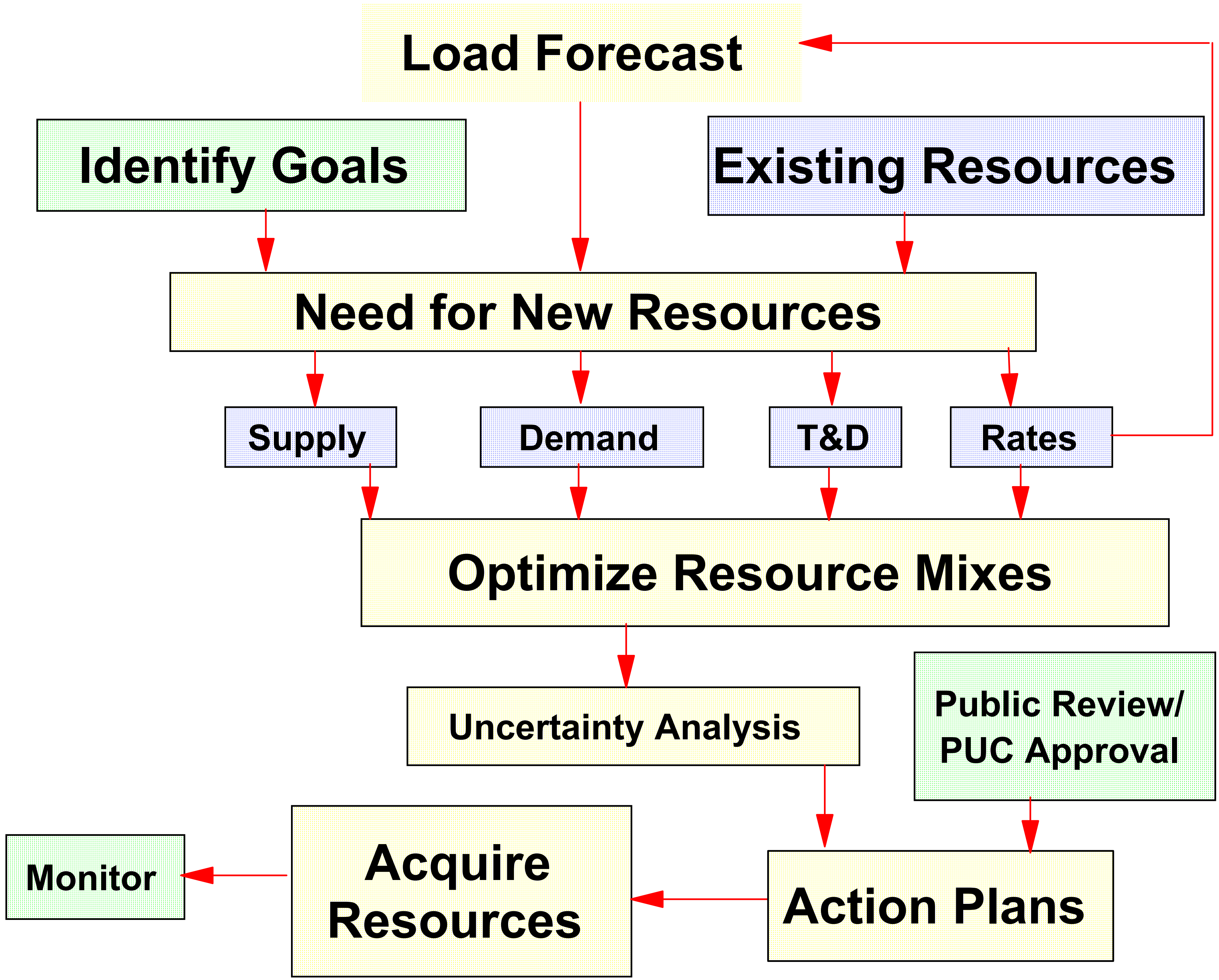
- Energy resources optimized to meet forecast demand
- Reduce total system costs
- Uses demand-side resources as well as supply-side resources
- Objective is lowest (total) cost energy services
- Maximize benefit for total $ spent

Least-Cost Integrated Resource Planning

- Reduces volatility of demand
- Enhances reliability
- Reduces the need for large-scale capital construction
- Reduces environmental impacts

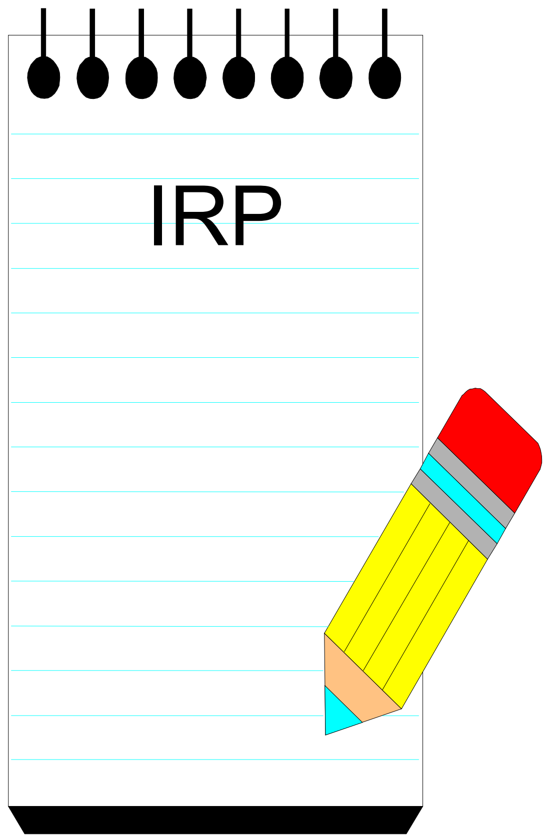
Least-Cost Integrated Resource Planning

- A change in the way the electric system is planned and built
  - A recognition of the economic component of the resource acquisition process
  - **Need** is an economic concept, not simply an engineering one


Load Forecast
Identify Goals
Existing Resources
Need for New Resources
Supply
Demand
T&D
Rates
Optimize Resource Mixes
Uncertainty Analysis
Public Review/
PUC Approval
Monitor
Acquire
Resources
Action Plans

Elements of IRP

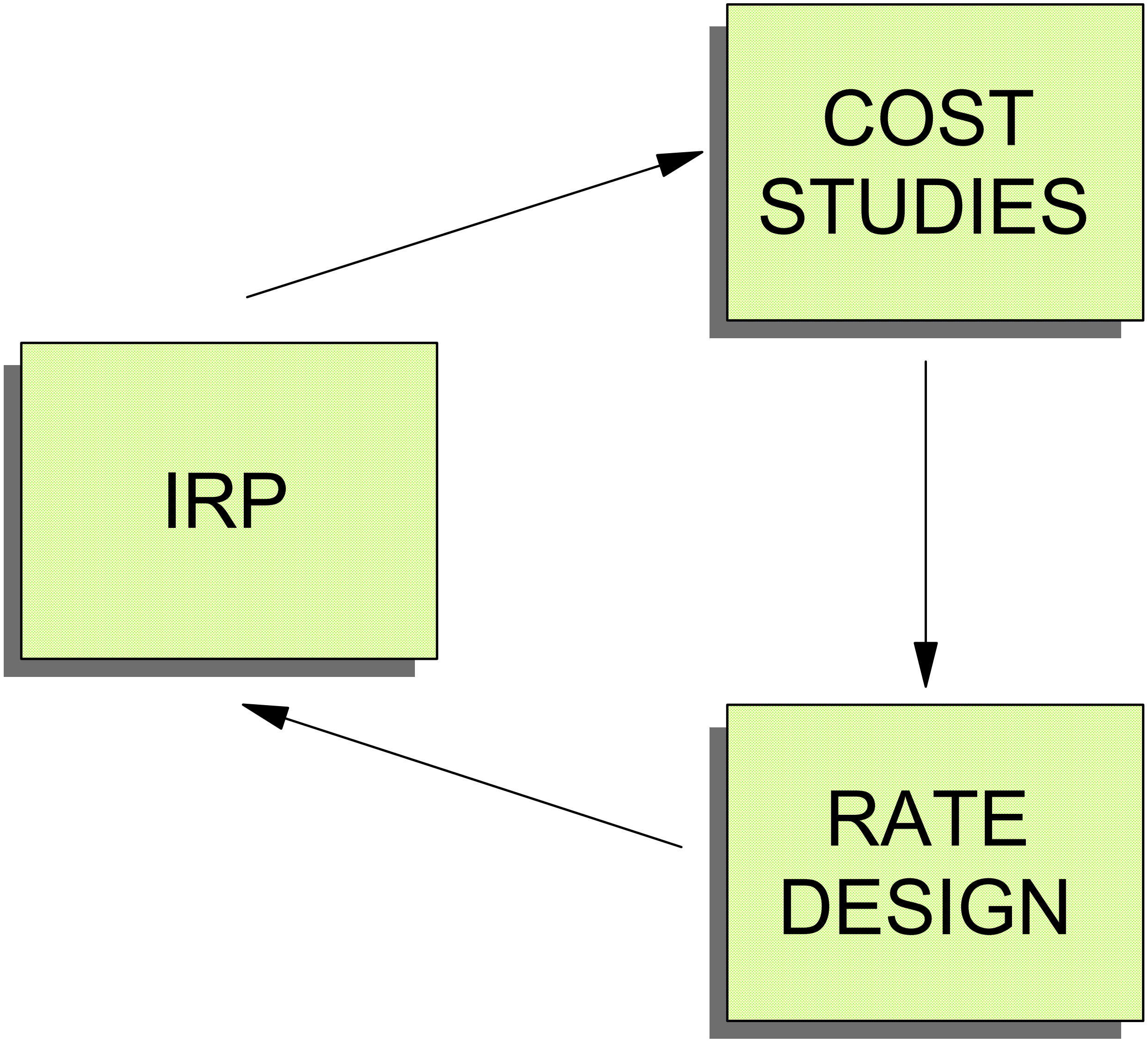
- Define planning objectives
- Define planning period
- Forecast demand
- Identify resource options
- Optimize resources to meet IRP objective
- Long-term plan/Action plan
- Public participation
- Implementation



Forecast Energy Service Demand

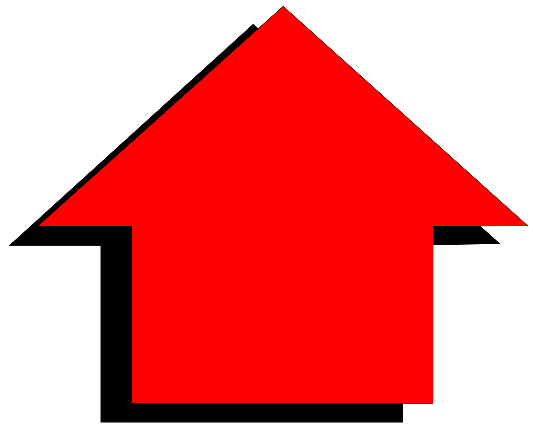
- Build from bottom up
- End use forecasts
  - Building stock
  - Appliance stock, standards
  - Energy intensity
  - Self-generation
- Load losses pose serious problem
- Price elasticity feedback

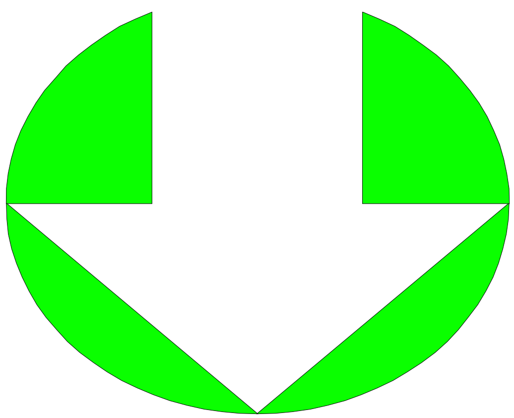
IRP - Rate Design Process Loop



Identify Resource Options

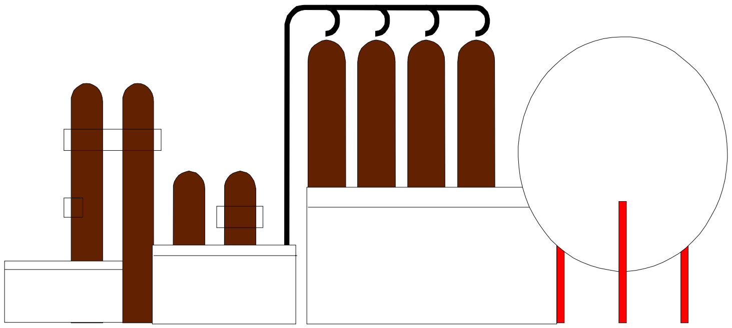
- Supply side





- Demand side

Supply-side Options Examples



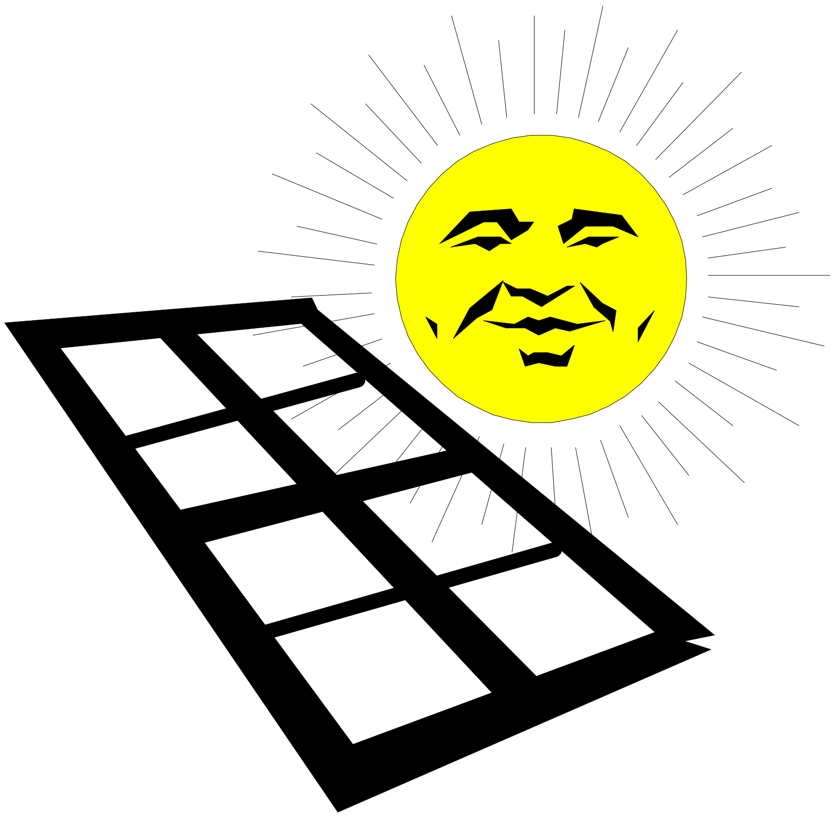
- Conventional plants
  - Large fossil-fueled
  - Nuclear
  - Small combustion turbines
  - Life extensions of existing plant
  - Transmission expansion or upgrade
  - Reduced transmission losses
  - Advanced transformers

Supply-side Options Examples

- Non-utility owned generation
  - Cogeneration
  - Small-scale hydro
  - Self-generation
  - Independent power producers
- Purchases
  - Requirements transactions
  - Coordination transactions

Supply-side Options Examples

- Renewables
  - Geothermal
  - Solar
  - Wind

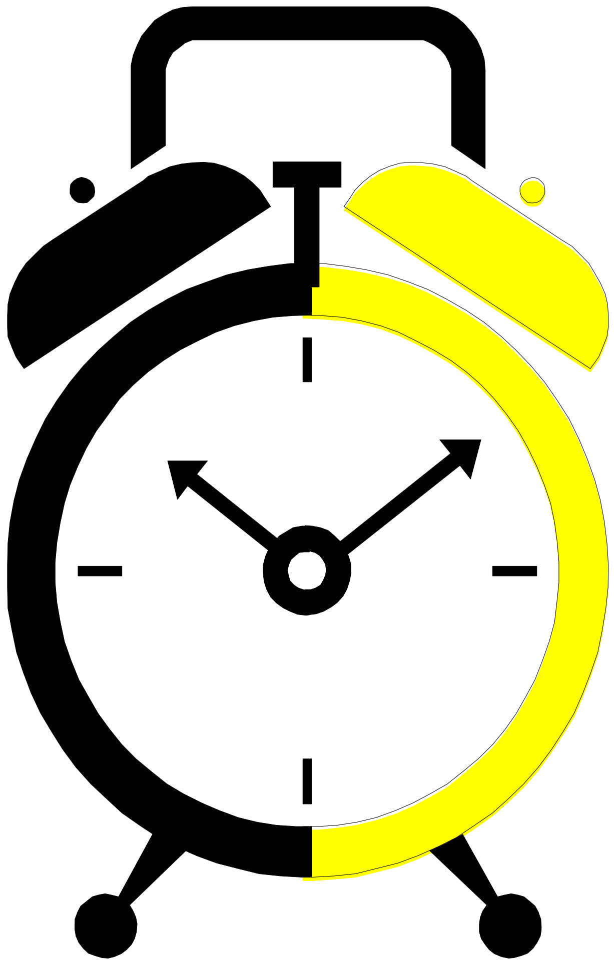


Demand-side Options Examples

- Energy-efficiency options (customer)
  - Home weatherization
  - Energy-efficient appliances and lighting
  - High-efficiency heating, ventilating and air conditioning
  - Load management
  - Utility control of appliances
  - Manufacturing process improvements
- Passive solar modifications

Rate Design Options

- Time of use
- Interruptible
- Incentive



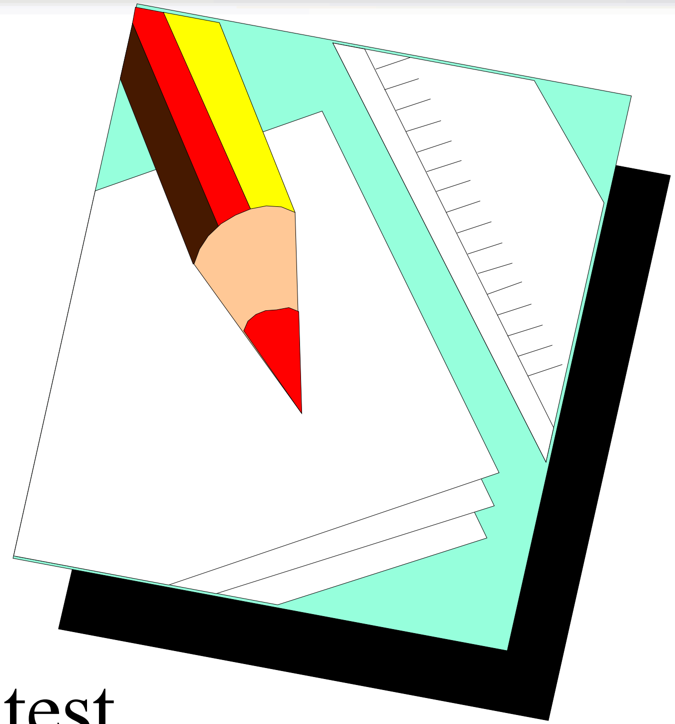
Cost of Options

- Life cycle costs
- Fixed costs vs. variable costs
- Environmental and other externalities
- Other attributes
  - Fuel diversity
  - Technological and other risks
  - Fuel cost uncertainty

DSM Cost Effectiveness Perspectives

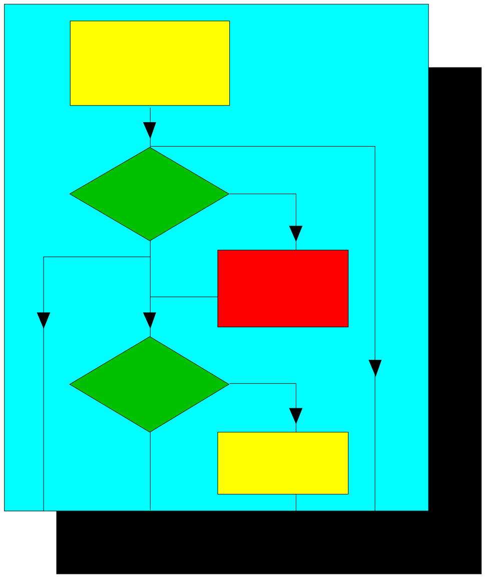
- Different interests have different economic criteria
  - Consumers
  - Utilities
  - Society
- Different interests see different costs and benefits
- Therefore, multiple perspectives for determining cost-effectiveness

Cost Effectiveness Tests



- Participant test
- Rate impact test (non participant, no losers test)
- Utility (revenue requirements) test
- Total resource cost (all ratepayers) test
- Societal test

Optimize Resources



- Find the mix of resources that minimizes the total cost of energy services
- Judgment and modeling
- Iterative process
- Uncertainty analysis - consider sensitivities; least-cost is low cost for a wide range of plausible scenarios

Public Participation

- Technical workshops
- Collaboratives
- Public hearings

Utility Participation

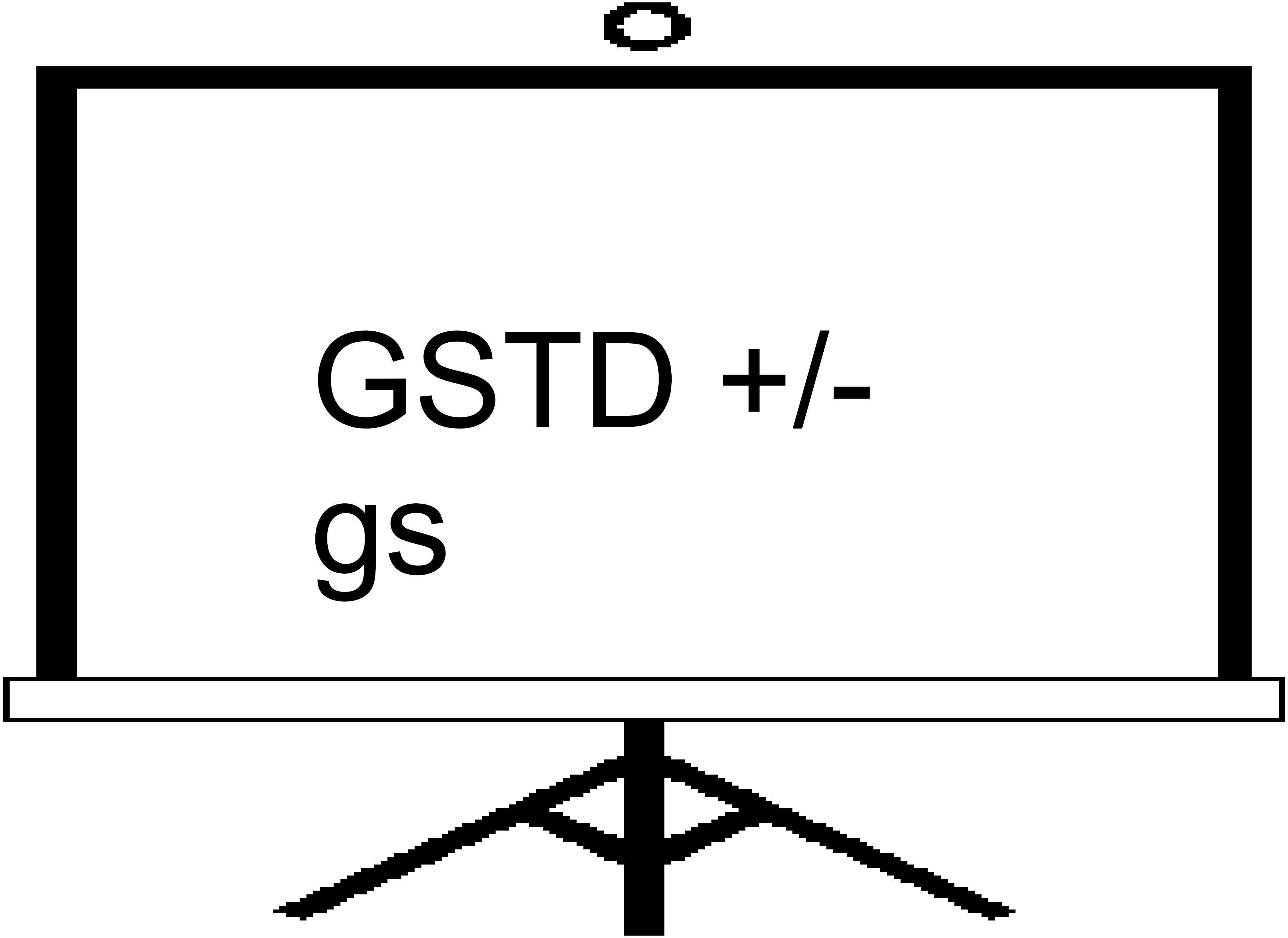
- New corporate skills
  - Integrated analysis
  - Demand-side program design and implementation
  - Analysis of external costs
  - Marketing operation and maintenance of different facilities
  - Organizational changes

Align Utility's Interest to IRP

- Internal incentives which match new IRP paradigm
  - Salary
  - Promotions
- External incentives
  - Profit
  - Public recognition

Policy Decisions for the Commission

- What is the IRP objective
- How can market forces be used in the IRP process
- How can regulation harmonize the interests of ratepayers and shareholders
- Should the commission approve utility IRPs
- How can the commission build an effective process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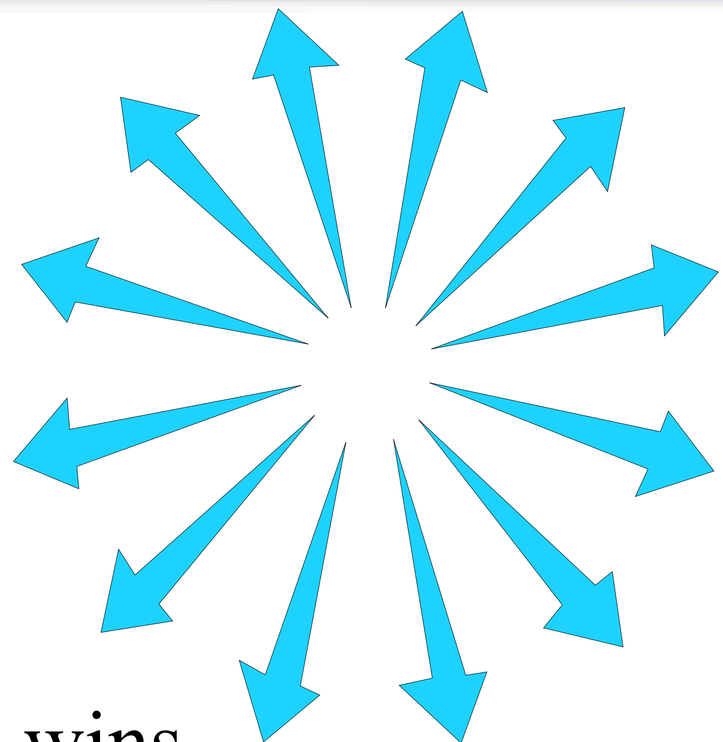
Planning Models

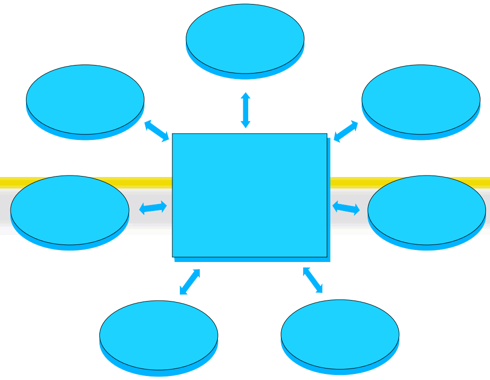
- Optimization Models
  - UPLAN
  - PROMOD
- Financial Models
  - ELFIN
  - UPLAN
  - @RISK
- Forecasting Models
  - REMI
  - Energy 20/20

IRP and Competition



- The goal of IRP is to reduce costs
- Competition is a means to help get us there
- IRP is needed to tell you who wins
- The more diverse the resources, the more you need IRP

History

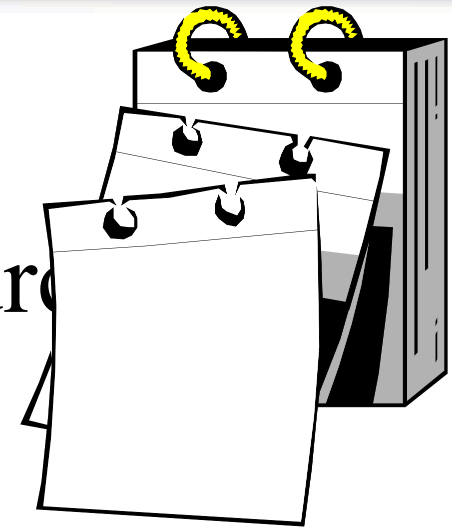


- Natural outgrowth of IRP
- First bidding in 1984 resulting from supply exceeding demand
- Bidding is now common practice
- Many lessons learned along the way
- End result - very positive

U.S. Bidding Experience

RPSs Supply Demand	 164 111
MWs Requested Supply Demand	 42,849 33,555
MWs Bid Supply Demand	 467,000 3,757
MWs on-line Supply Demand	 8,752 148
States using bidding	37

Competitive Bidding



- Further expanded options
- Lower costs for similar resourc
- Innovative contracting
  - Options
  - Operational flexibility

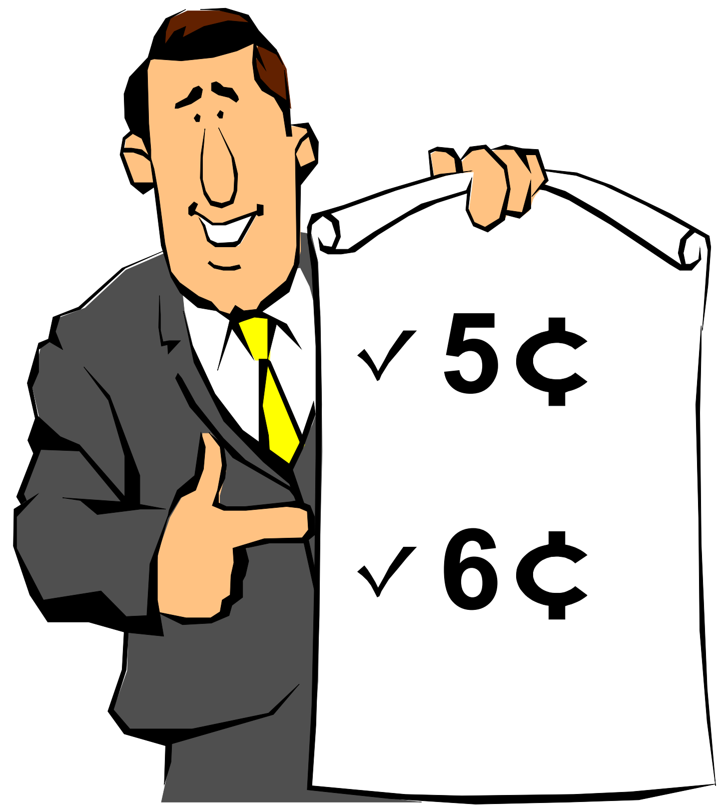
Avoided Cost

Avoided Cost Analysis is Key to Optimal Integration

- A new resource should be added whenever it is cheaper than the existing or planned resource it displaces
- Each hour in each year has its own avoided cost
- The value of a new resource is determined by what it displaces

Test

- You get a 5-cent bid and a 6-cent bid
  - **Who wins?**
  - **What is your avoided cost?**



What is the Product?

- EQS
  - How dispatchable
  - What is min load, ramp rate, startup cost
  - What is forced outage rate
  - How long are scheduled outages/can util schedule
  - What is contract duration
  - Where is plant located
  - How does plant impact required reserve margins

- HQS
  - Pricing terms
  - Impact of resource options on fuel diversity
  - Security and perform. terms
  - Provisions for contingency, buy-out, deferral and cancel.
  - Developers' experience
  - Specific price and risk allocations
  - Buyer's risk
  - Future environmental regs cost

Next Test

- What if the 5-cent bid is worth 4 cents and the 6-cent bid is worth 7 cents?
- 5-cent bid costs more than AC
- 6-cent bid costs less than AC
- Avoided cost is ???????

Answers

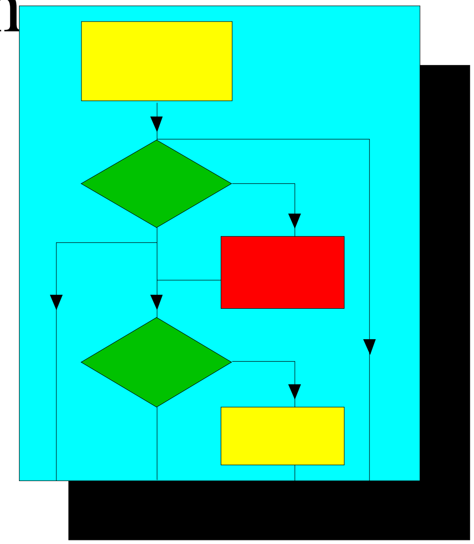
Who wins	can't tell
Avoided Cost	can't tell
How do we tell?	IRP, bid evaluation
Non Price	Sure - but utility and customers may differ

Avoided Cost Definition

- What is the greatest amount a society should be willingly to have its utility pay for a resource?

Planning Models

- Designed to analyze, firm conventional resources
- Renewables such as biomass and hydro are simple but reliability often missed (NEPOOL, PJM)
- The models do not easily analyze
  - Intermittent resources
  - Uncertainty/risk
  - Relative environmental impacts
  - Distributed benefits



Two Types of Avoided Cost

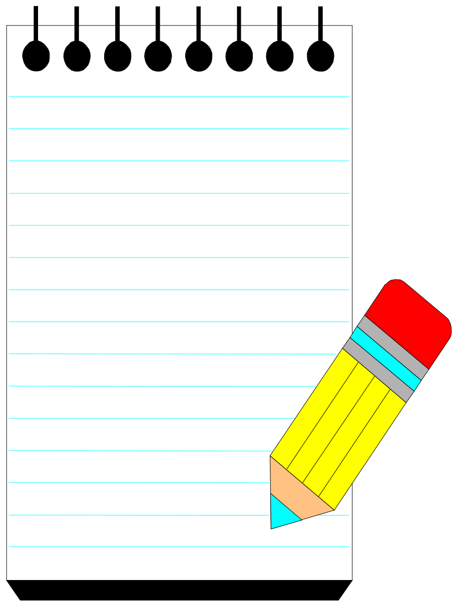
- Generic avoided costs, based on an arbitrary standardized resource
- Customized avoided costs, based on specific characteristics of an actual resource
- NOT simply the cost of next plant

Components of Total Avoided Costs

- Avoided generation costs including fixed, variable, and reliability costs
- Avoided line loss costs
- Avoided T&D costs
- Avoided direct environmental costs
- Avoided direct economic costs
- Avoided indirect economic costs
- Avoided administrative and OH costs

Major Steps in Avoided Cost Analysis

- Compile full list of alternative resources
  - Supply side
  - Demand side



- Develop and cost out alternative plans
- Optimize / Choose best plant

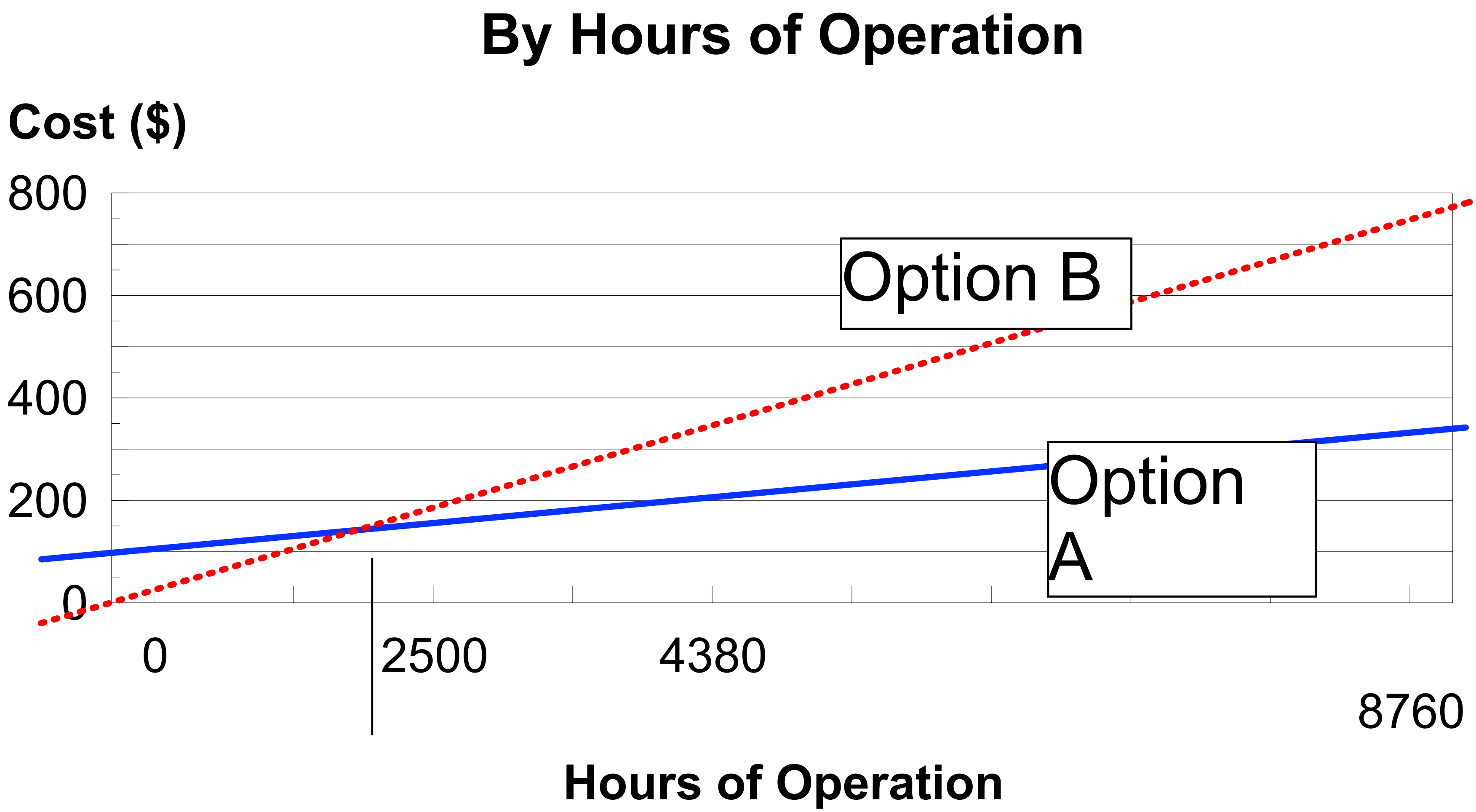
Traditional Supply Optimization

Simple Example -- Two Options

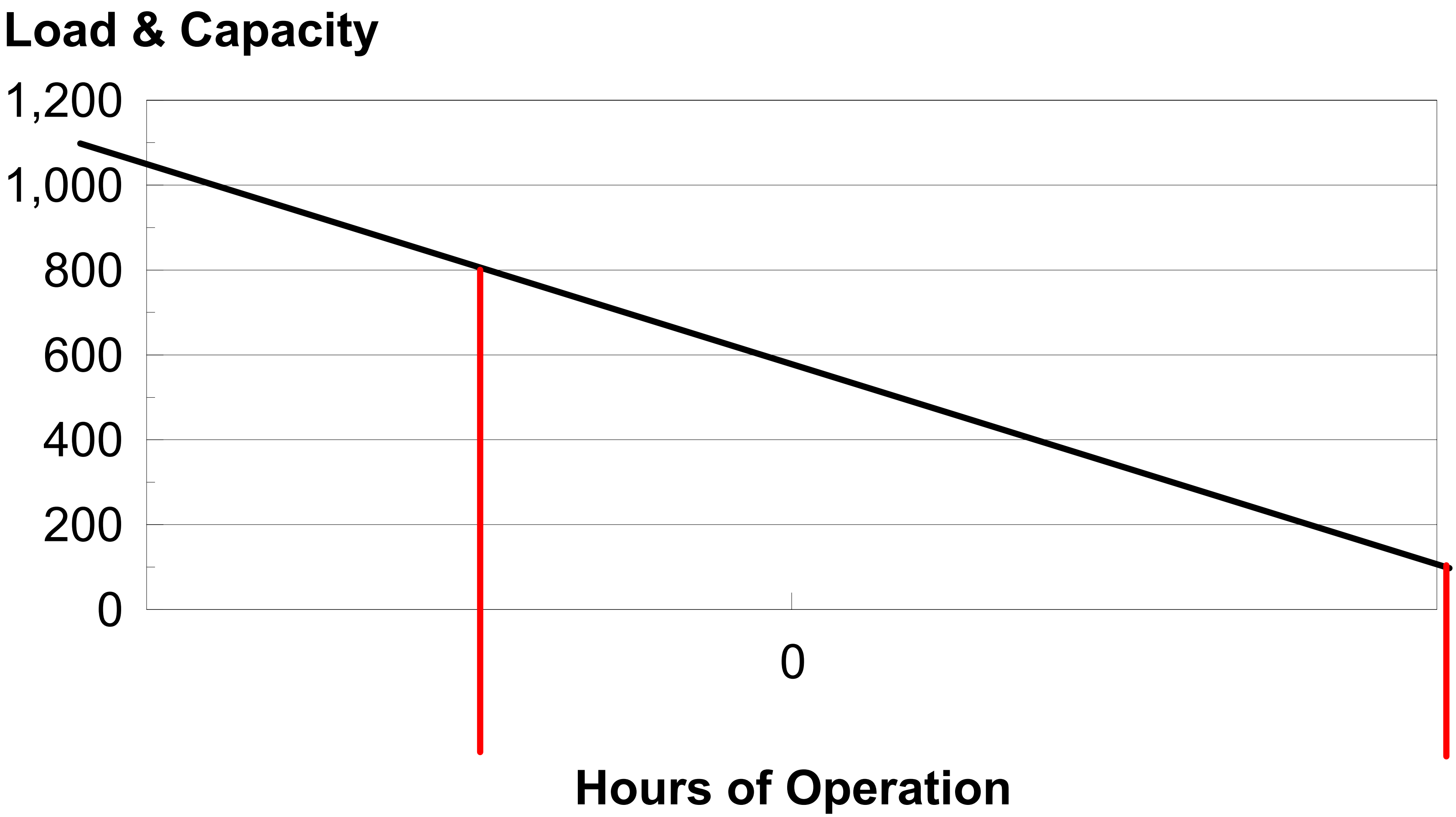
	Investment	Annualized Capital Cost	Fuel Cost
#1	$1000/KW	$200/KW	$.02/kWh
#2	$500/KW	$100/KW	$.06/kWh

How much of each do we want?

Cost of Options



Load Duration Curve
and Resource Acquisition



Base Plan

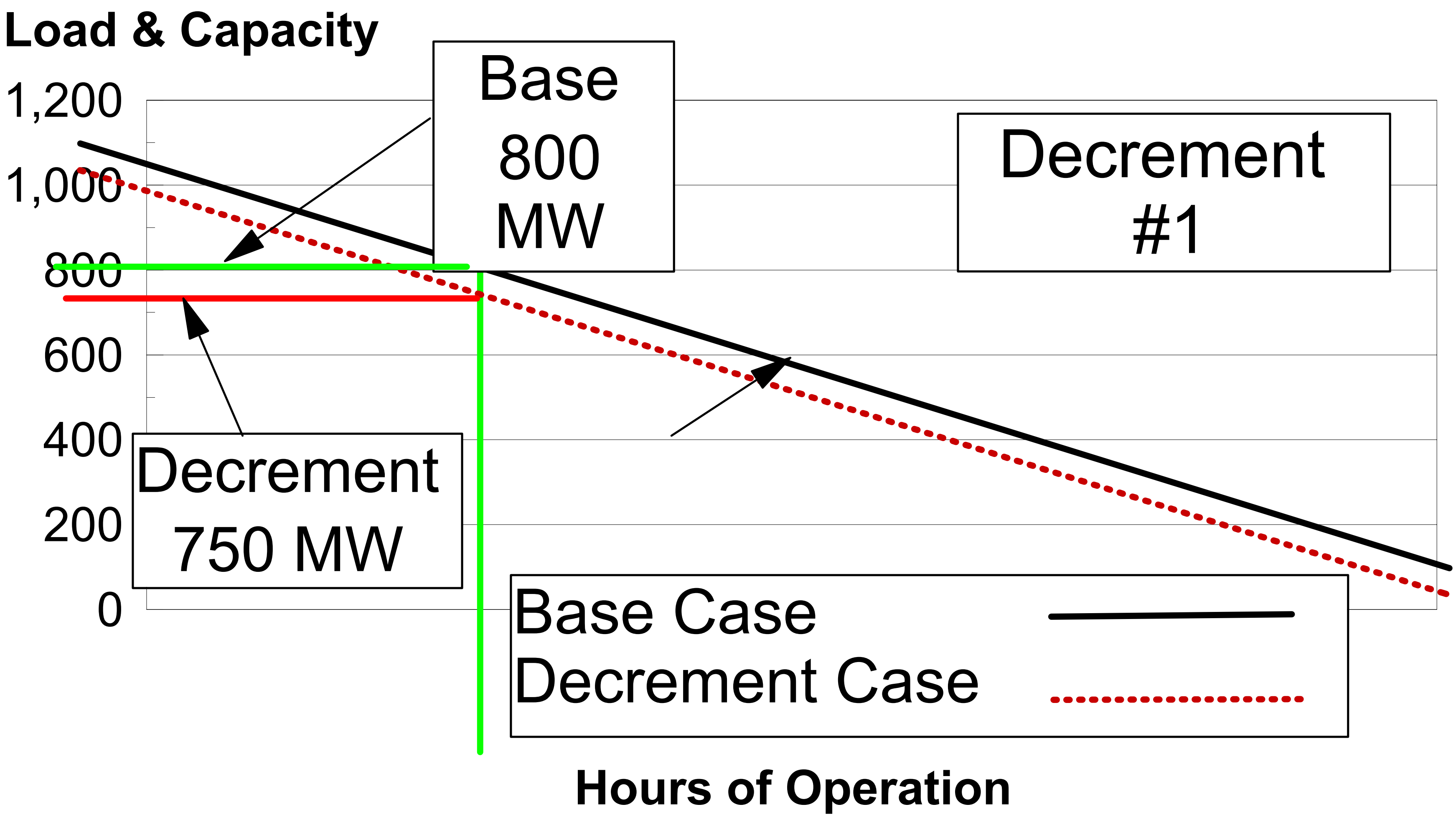
- 800 MW of Option A
- 200 MW of Option B
- Total Cost = $303.9 million

Decrement #1

- 50 MW less in every hour
- Plan #1
  - 750 MW of Option A
  - 200 MW of Option B

Total Cost = $285.1 million
Avoided Cost = $303.9 - 285.1 = $18.8 million, or 4.3 cents/kWh

Load Duration Curve
and Resource Acquisition



Decrement #2

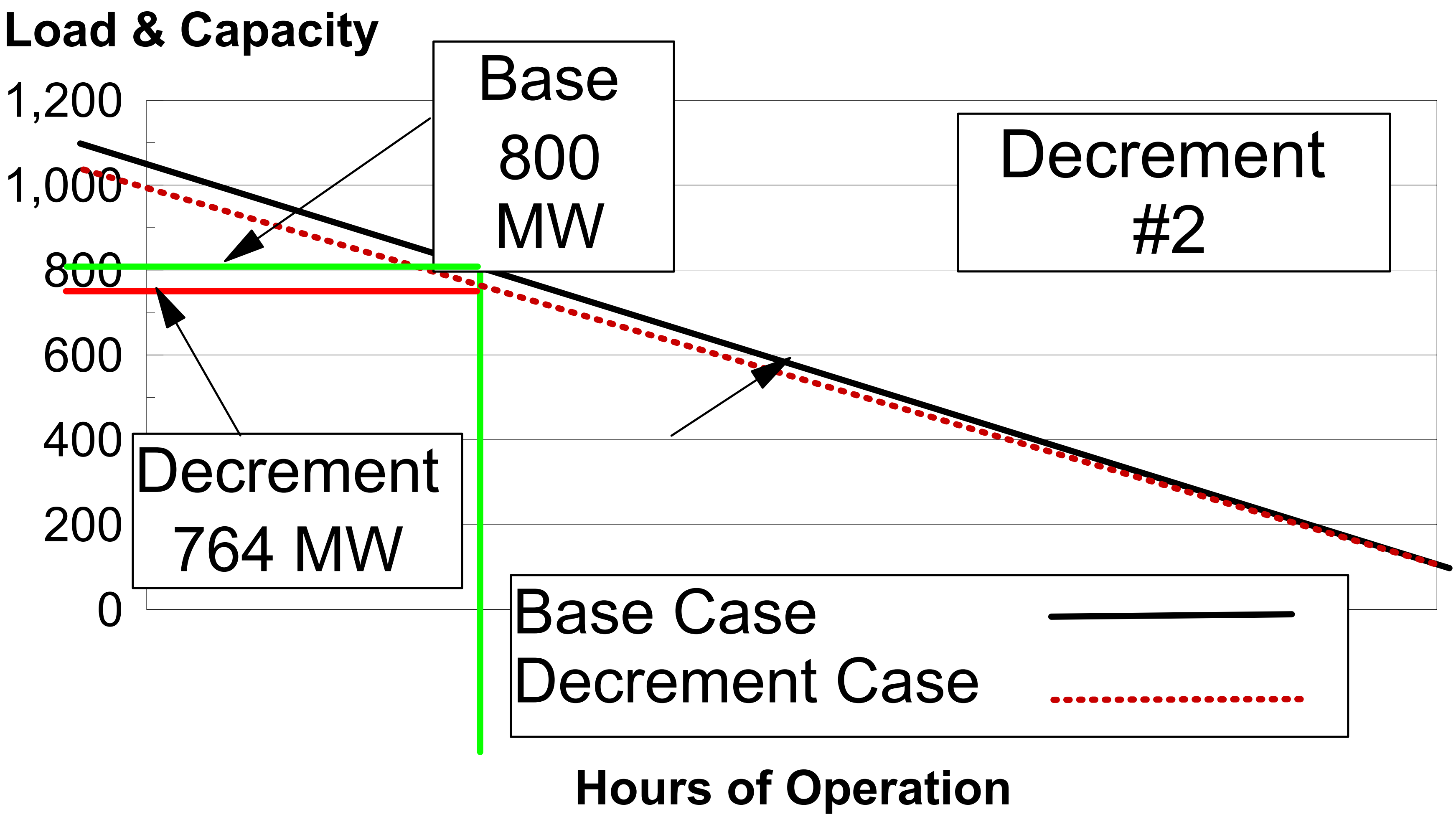
- 50 MW less on peak
- No change in lowest load

- Plan #2
  - 764 MW of Option A (36 less)
  - 186 MW of Option B (14 less)

Total Cost = $290.2 million

Avoided Cost = $303.9 - 290.2 = $13.7 million, or 6.3 cents/kWh

Load Duration Curve
and Resource Acquisition

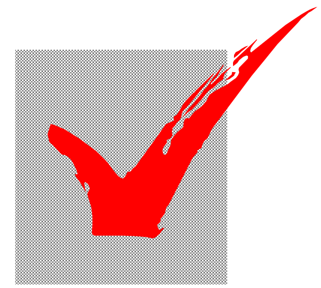


Common Mistake #1

- The avoided cost is ___ cents per kWh
  - Avoided costs vary year by year
  - Avoided costs vary within any given year
- Examples
  - Base load vs. peaking resources
  - Dispatchable vs. non-dispatchable sources
  - Intermittent sources
  - Location on T&D system
  - Reliability effects

Common Mistake #1 (cont'd.)

- Conclusion



  - Every resource has its own "customized" avoided cost
  - No two resources will have the same avoided cost.

Common Mistake #2

Surplus Capacity means avoided costs are zero

- There are always avoided Fuel Costs
- Often avoided transmission and distribution costs
- Once surplus is gone, avoided generation capacity costs will occur
- The risk profile is lopsided

Cost, Worth, and Need

- Bids, bus bar cost, etc.:
  - Tells you what a resource costs
- IRP, avoided cost:
  - Tells you what a resource is worth
- Need:
  - Any resource that costs less than it is worth

Common Mistake #3

- There are no Avoided T&D Costs
  - Line losses
  - T&D capacity Costs
    - Distributed Benefits
    - Targeting resources to areas which would otherwise need T&D upgrades

Avoided T&D System Costs

- Construction costs
- Licensing costs
- Operation costs (fixed and variable)
- Maintenance costs (f & v)
- Note: Marginal losses can be two, four or more times average losses and transmission can be very expensive

Common Mistake #4

- Intermittent resources have no capacity value
  Question: Do intermittent loads e.g. water heaters, create capacity costs?
- Answer: yes

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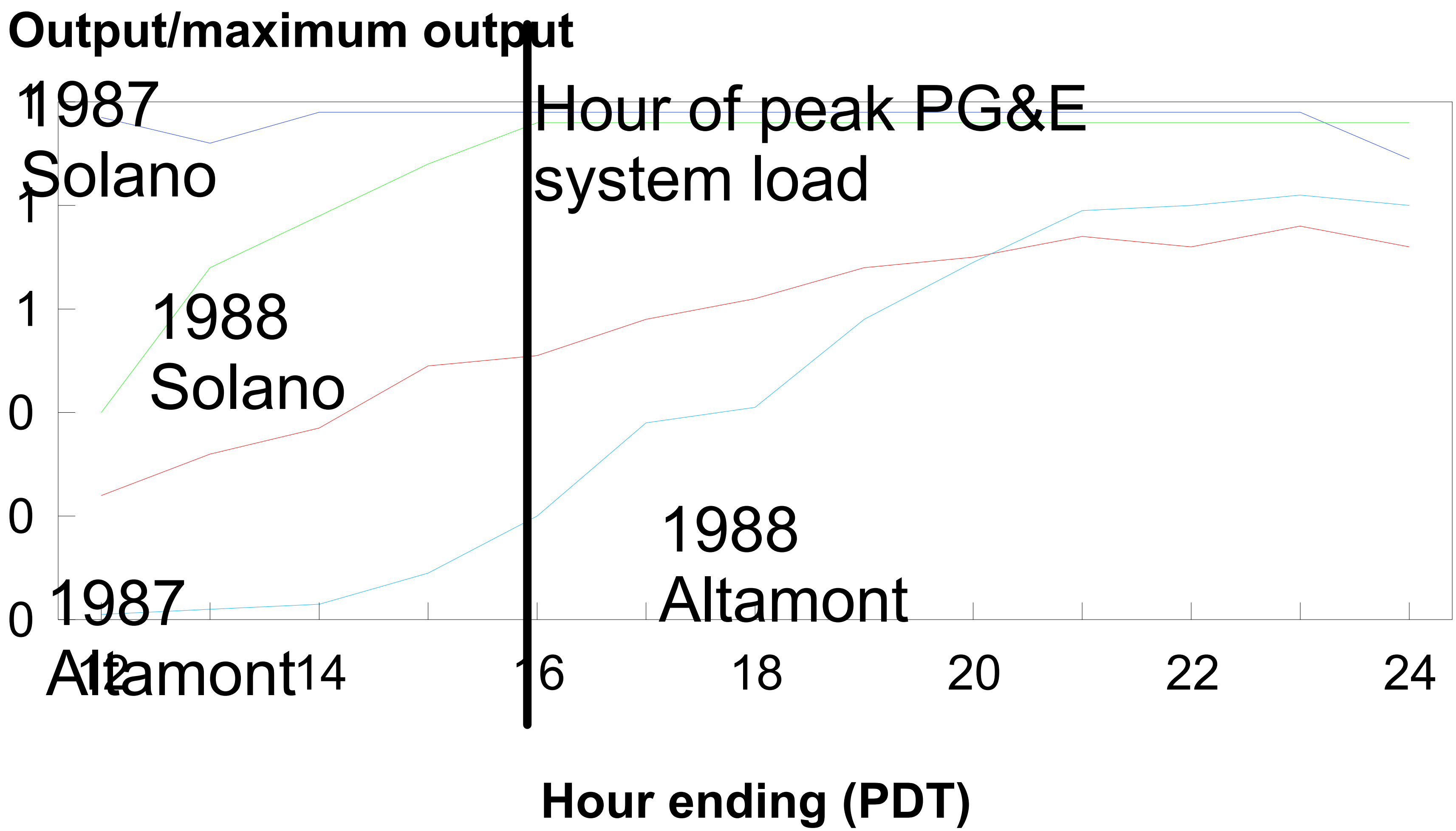
- **Then intermittent supply has capacity value. The question is how much and whether RTP and other capacity options are least-cost**

Wind Plant Output During PG&E Peak Load Days



Common Mistake #5

- A "proxy" plant can be used to accurately calculate avoided costs
  - Typically, the difference between the two optimal resource plants will be attributable to *delays* in a series of new generating units as well as to changes in the *mix* of new baseload, cycling and peaking units.

Common Mistake #6

- Goals = Constraints
- Ownership of resources
- Supply-side only
- Dispatchability
- Exposure to individual risks, e.g. fuel supply

Avoided Direct Environmental Costs

- Three components
  - Costs of emissions allowances
  - Costs of pollution control retrofits
  - Cost of compliance with probable future environmental requirements

Avoided Environmental External Costs

- Avoided costs of damages that would potentially be inflicted on the environment as a result of:
  - construction of energy facilities
  - extraction, processing, transport, combustion and disposal of waste and spent fuels
  - consumption of electricity at the point of end-use
  - land and water impacts

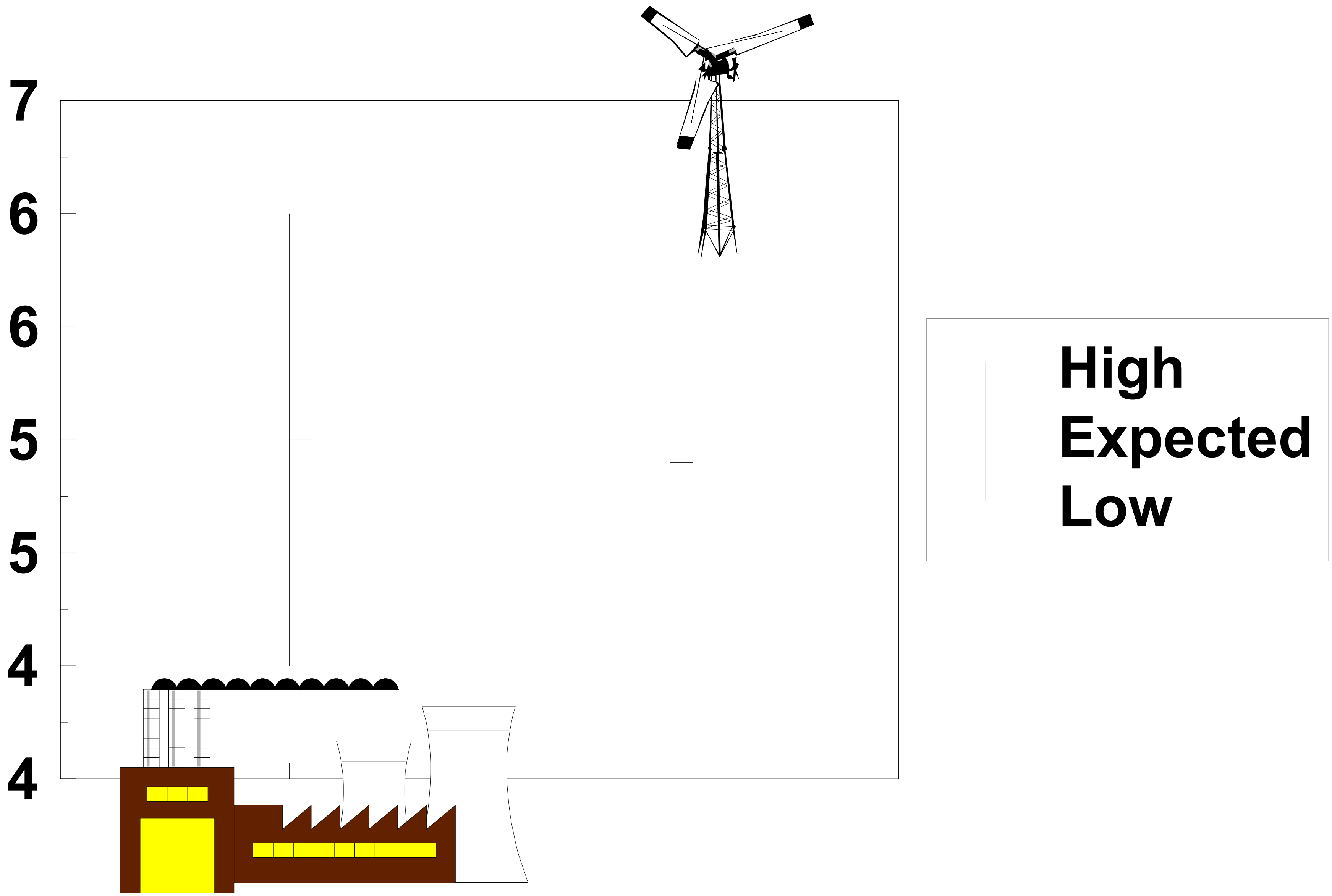
Judgment is Unavoidable

- Part policy and judgment, part analytics
- Policy and judgment are important because:
  - many important considerations are too difficult to quantify
  - utility risk assessment may differ from consumer's perspective

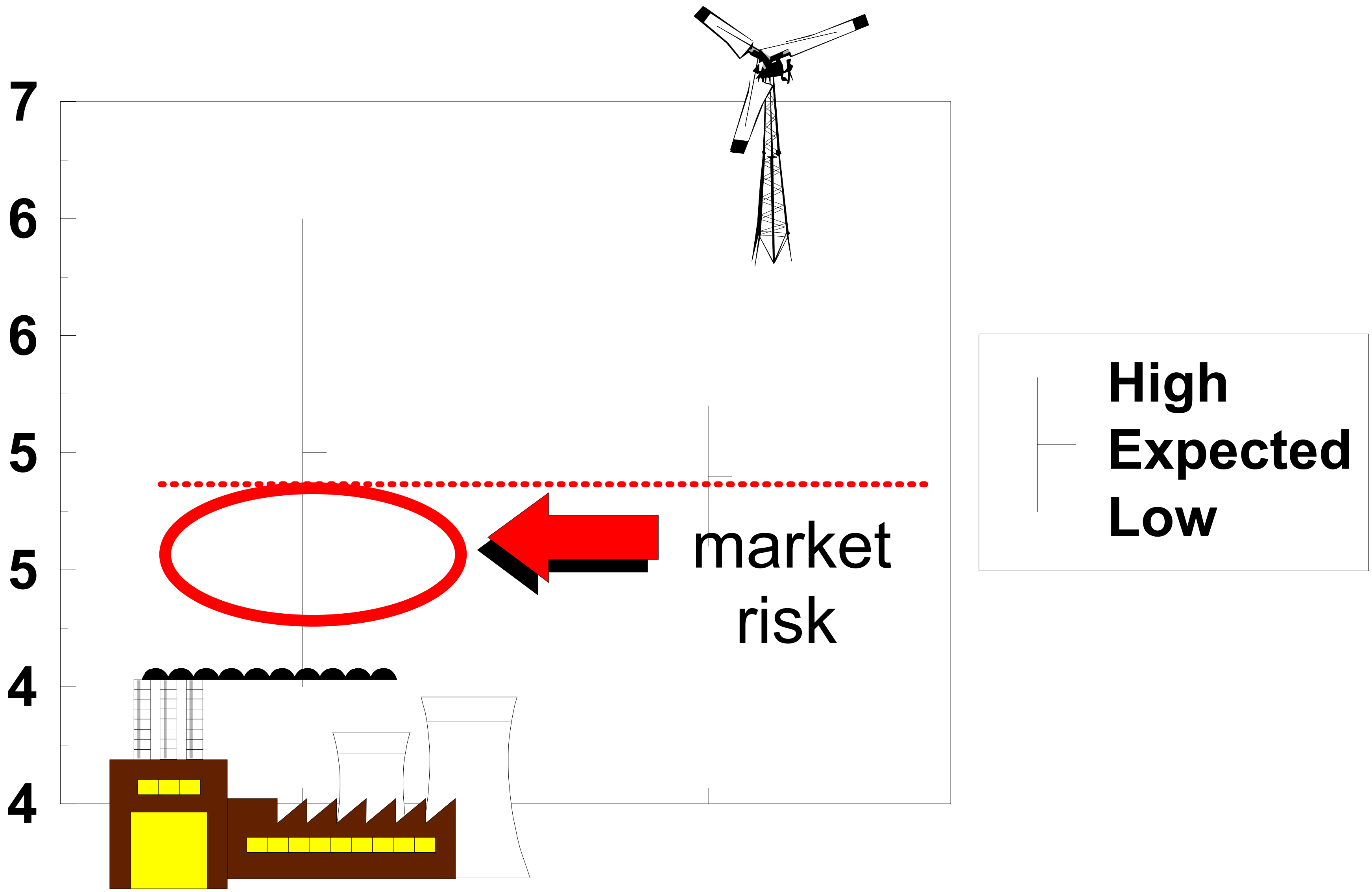
Qualitative Aspects

- Diversity
  - Oil dependence
- Risk
  - Price volatility
- Environment (can be quantitative)
  - Tourism
- Economic Development   Exporting $

Risk Analysis



Market Risk for Renewable Resources

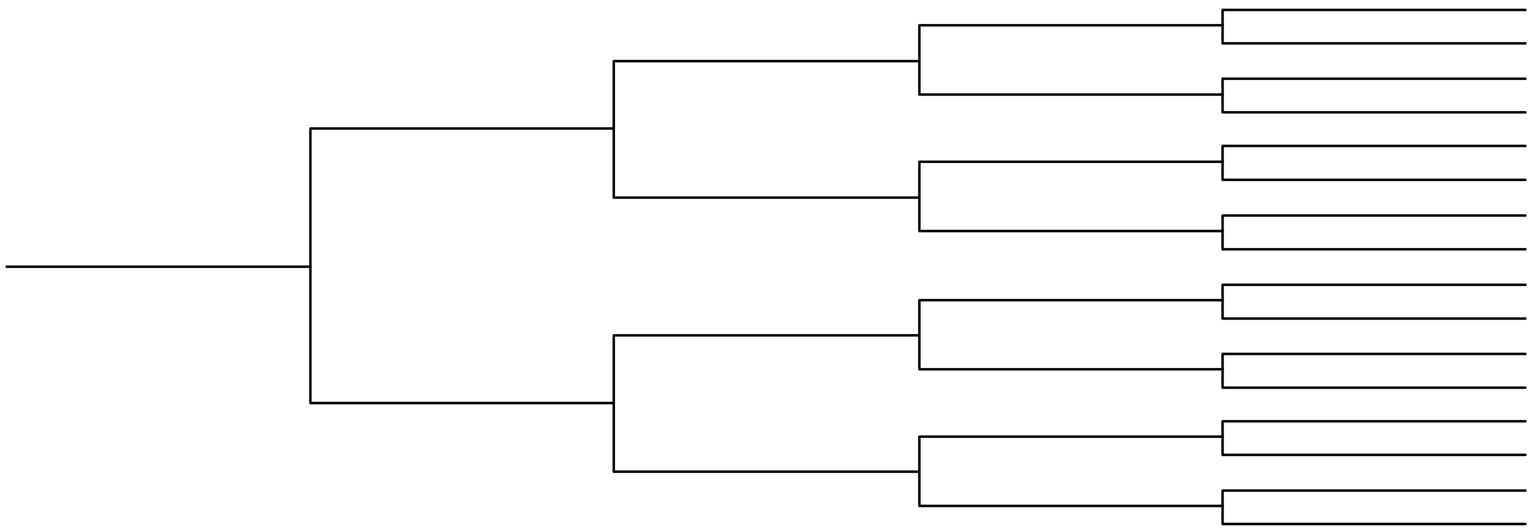


What are the Typical Risks?

- Resource Level
  - Cost
  - Performance
  - Permitting/Lead time
- System Level
  - Fuel Costs
  - Load Growth
  - Technological Change
  - Environmental
  - Regulatory/Market Structure

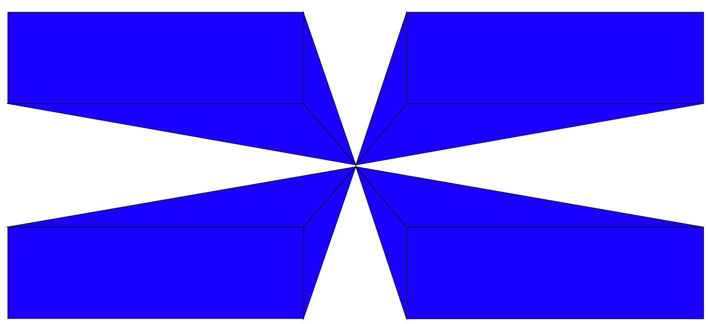
Analytical Tools

- Sensitivity (and Scenario)Analysis
- Risk Adjusted Discount Rates
- Options Theory
- Decision Tree Analysis



One Minor Problem

- Need to know:
  - Range of possible values for each risk
  - The likelihood of each value
  - The interactions among them
  - Implications of risk allocation
- History shows we don't do that very well



Fuel Example

- Avoided costs are heavily influenced by oil price forecasts
- Bad Option: Tie contract payments to actual oil prices
- Better Option: Fix prices based on today's forecast
- Best Option: Option 2 plus use market to firm long-term oil price and place fuel risk on utility

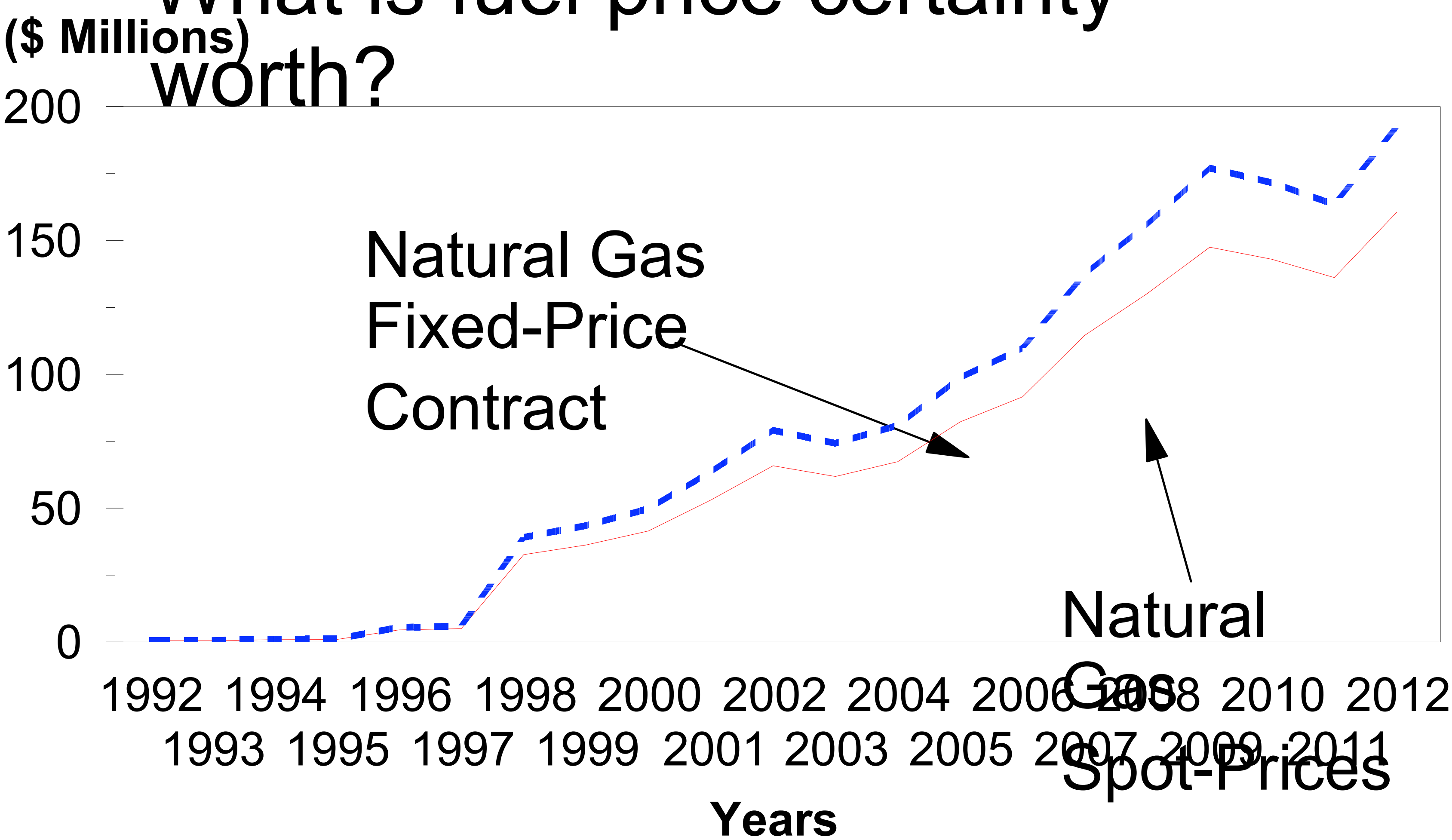
Economic Impacts

IMPACT OF BIOMASS INDUSTRY ON MAINE ECONOMY

Capital investment	$1 billion plus
Employment	1,800-3,300
GSP	$120-220 million

Risk Adjusted Example
Page 1

What is fuel price certainty worth?



Risk Adjusted Example
Page 2

	Projected Spot-Prices	Fixed-Price Contract
Traditional Results:	$ millions	
WACC-Based Value	$388.0	$465.6
Risk-Adjusted Results:		
Market-Based Value	$1,260.2	$1,072.3

Risk-Reduction Benefits of Renewables

- Modularity, environmental, no or low fuel cost uncertainty, resource diversity, use of indigenous energy resources, national energy security issues

Renewable and Risk Analysis

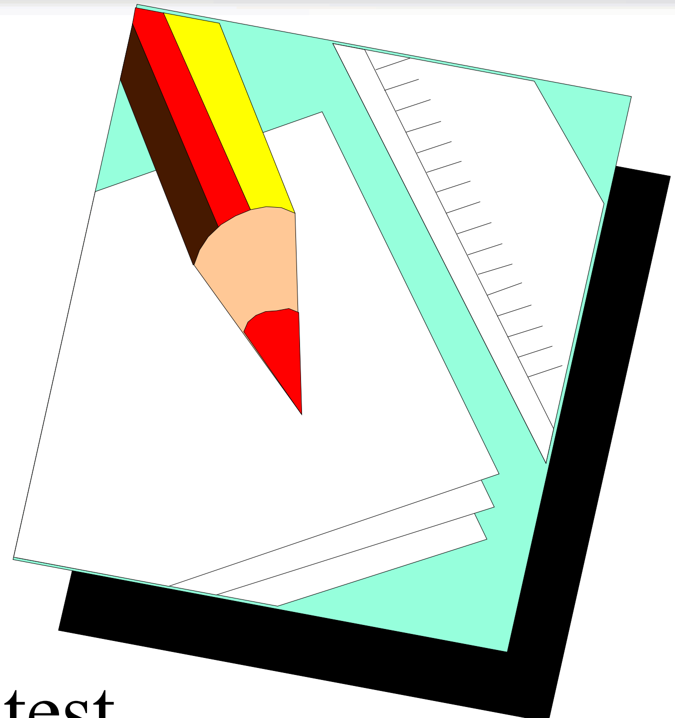
- The planning tools were not designed with renewables in mind
- Quantifying the direct value of renewables can be improved
- Many of the most beneficial aspects of renewables require judgment more than analytics

Conclusions

- No established methodology for considering risk
  - Subjective judgment required
  - More elaborate models tend to obscure, not replace, the subjectivity

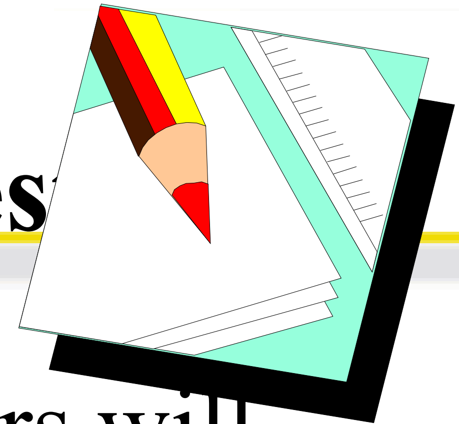
DSM

Cost Effectiveness Tests



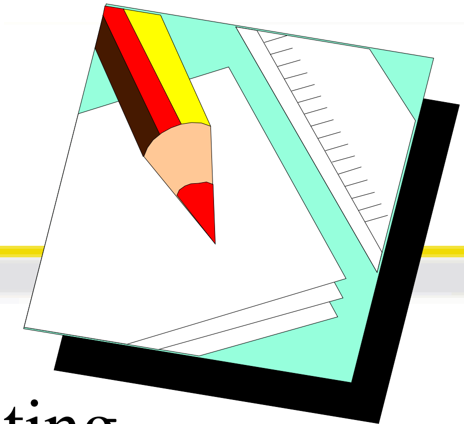
- Participant test
- Rate impact test (non participant, no losers test)
- Utility (revenue requirements) test
- Total resource cost (all ratepayers) test
- Societal test

Participant Tes



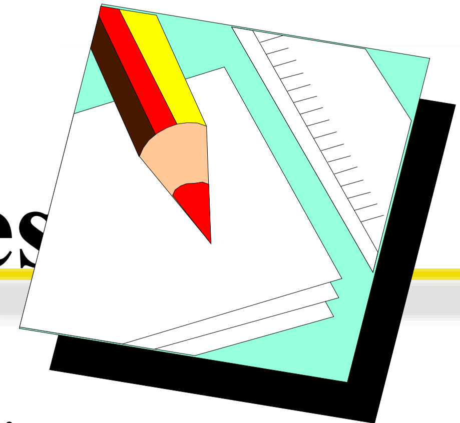
- Purpose: ensure that consumers will want to participate
- Are the economics sufficient to induce participation?
- Counts direct economic benefits received by participants
- Counts only costs incurred and borne by participants

Rate Impact Measure Test



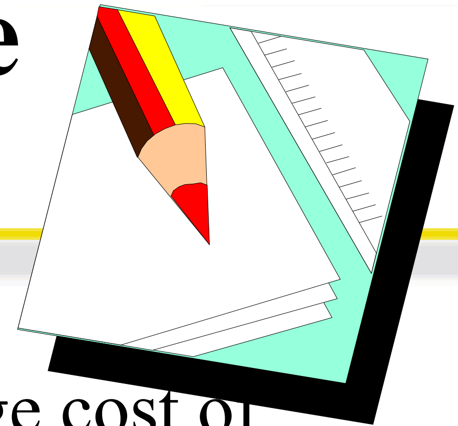
- Purpose: measure impacts on non- participating ratepayers
- Minimizes electricity prices - but will increase overall cost of energy services
- Benefits: utility avoided costs
- Costs: program costs and lost revenues
- Most restrictive test: program is cost effective only if it reduces rev. requirement.

Utility Cost Test



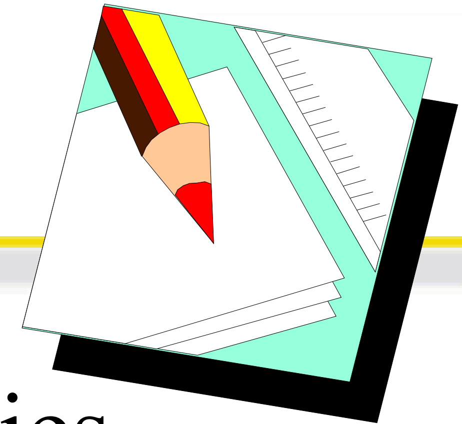
- Purpose: measure the change in cost to utility (revenue requirements)
- Easiest test to meet; most similar to a supply side test
- Assumes that regulators will keep the utility whole (ignores lost revenues)
- Benefits: utility avoided costs
- Costs: program costs (participant costs ignored)

Total Resource Cost Test



- Purpose: measures the change in the average cost of energy services across all ratepayers
- Minimizes total cost of energy services, but will increase the price per kWh
- Benefits: utility avoided costs
- Costs: program costs, participant direct costs

Societal Cost Test



- Purpose: incorporate externalities into analysis
- Like TRC, it ignores allocation of costs and benefits
- Unlike TRC, it draws the boundary of analysis more broadly, around society as a whole

Cost and benefits

	Benefits			Costs		
Economic perspec-tive	Avoided costs	Customer bill savings	Incentive payments	Program Costs	Customer Costs	Lost Revenue
Partici-pant test		X	X		X	
Rate test	X			X		X
Utility test	X			X		
Total resource cost test	X			X	X	
Societal test	X*			X	X	

*plus avoided environmental costs

Commercial Lighting Program Example

Costs

Program costs (planning and design, admin customer incentives, evaluation)

Customer costs (their share of measures costs)

Lost revenue

Benefits

Customer bill savings

Avoided costs

Avoided environmental externalities (10% of AC)

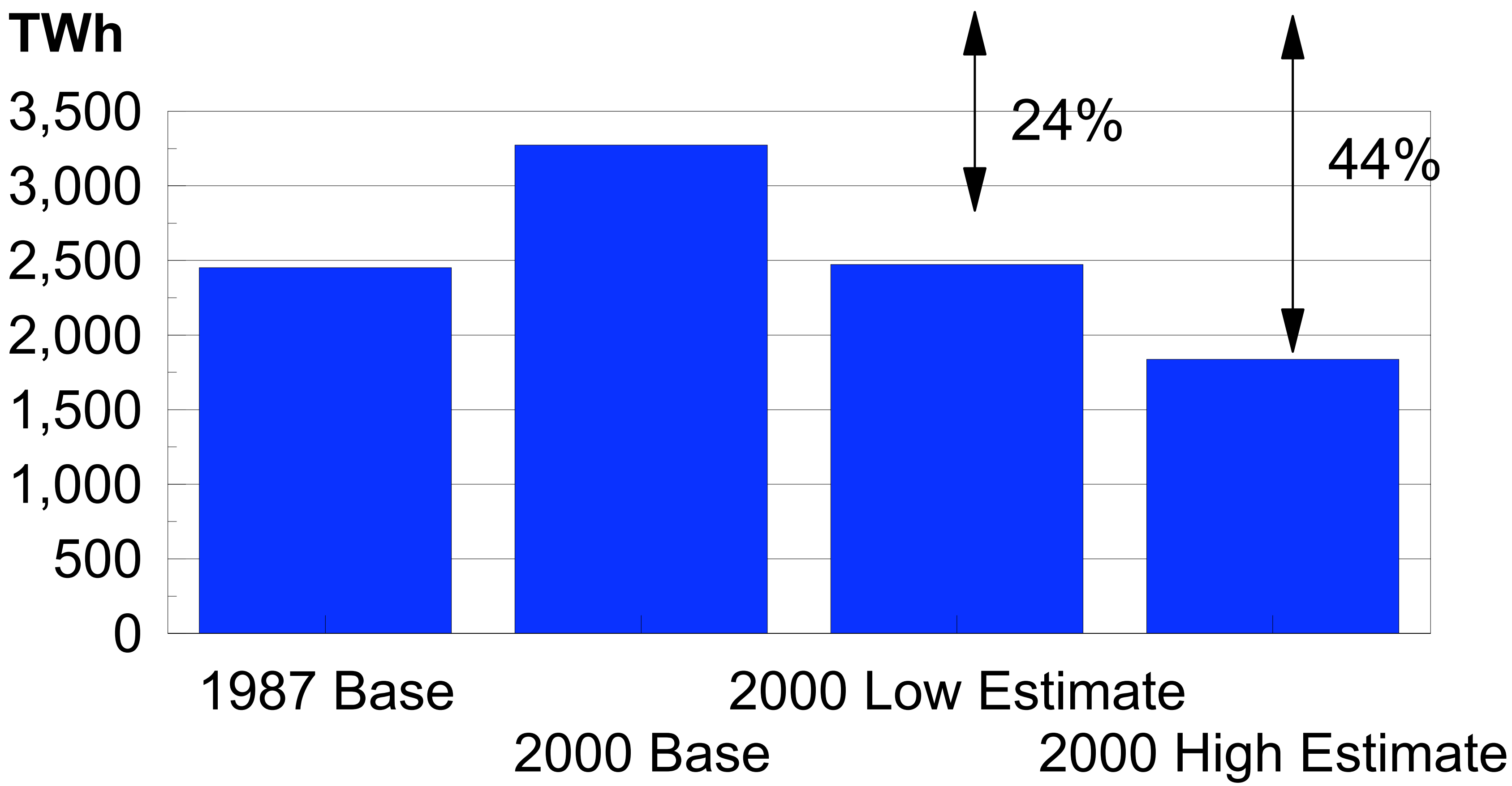
Commercial Lighting Program Example

Costs	$Million Present Value
Program costs (planning and design, admin customer incentives, evaluation)	10.0
Customer costs (their share of measures costs)	4.0
Lost revenue	44.0
Benefits	
Customer bill savings	44.0
Avoided costs	28.0
Avoided environmental externalities (10% of AC)	3.0

Commercial Lighting Program Example (cont.)

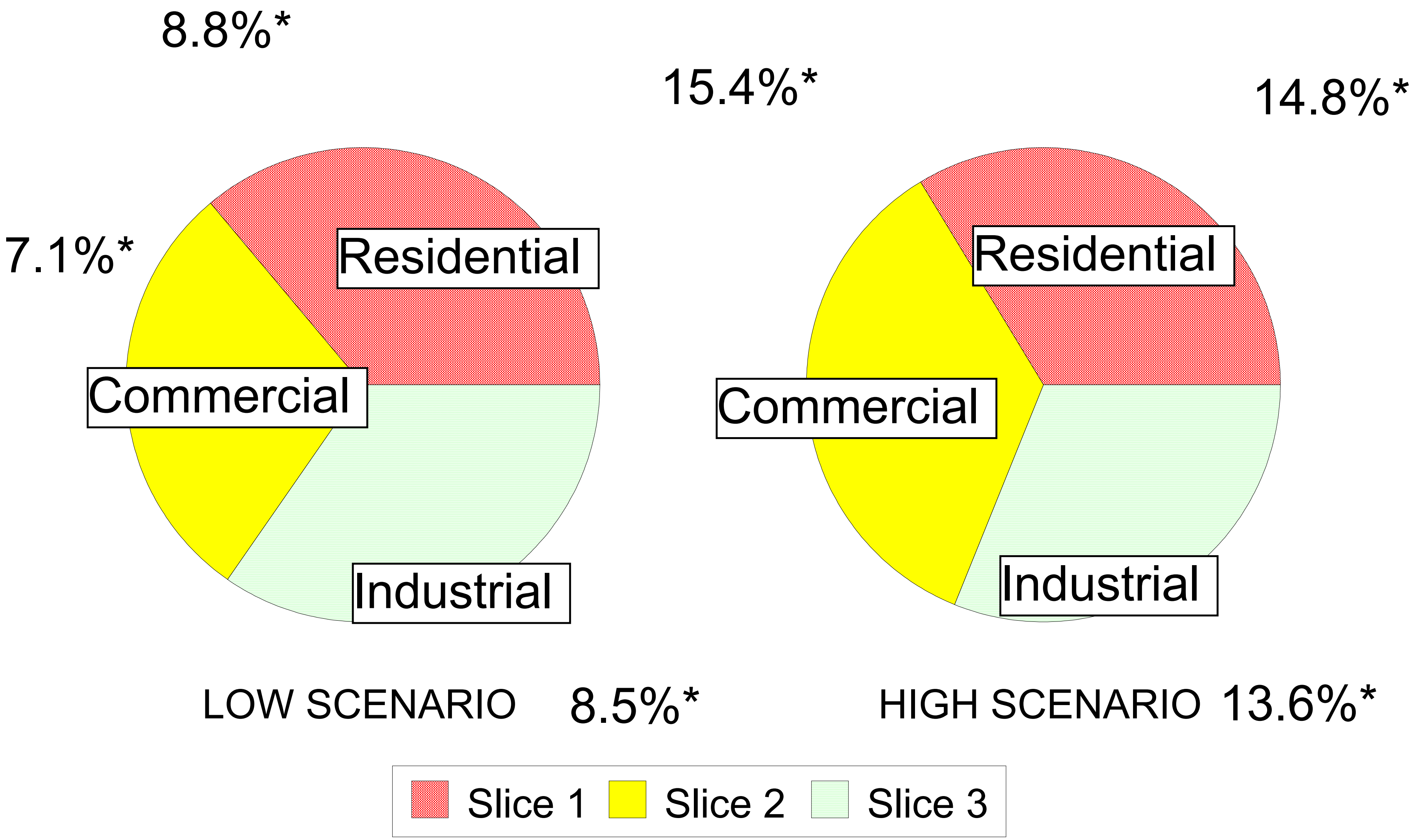
Economic Perspectives	PV Costs	PV Benefits	NPV	B/C Ratio
Participants	-4	+44	+40	11.0
Ratepayers	-54	+28	-26	0.5
Utility	-10	+28	+18	2.8
TRC	-14	+28	+14	2.0
Society	-14	+31	+17	2.2

Energy Efficiency Potential



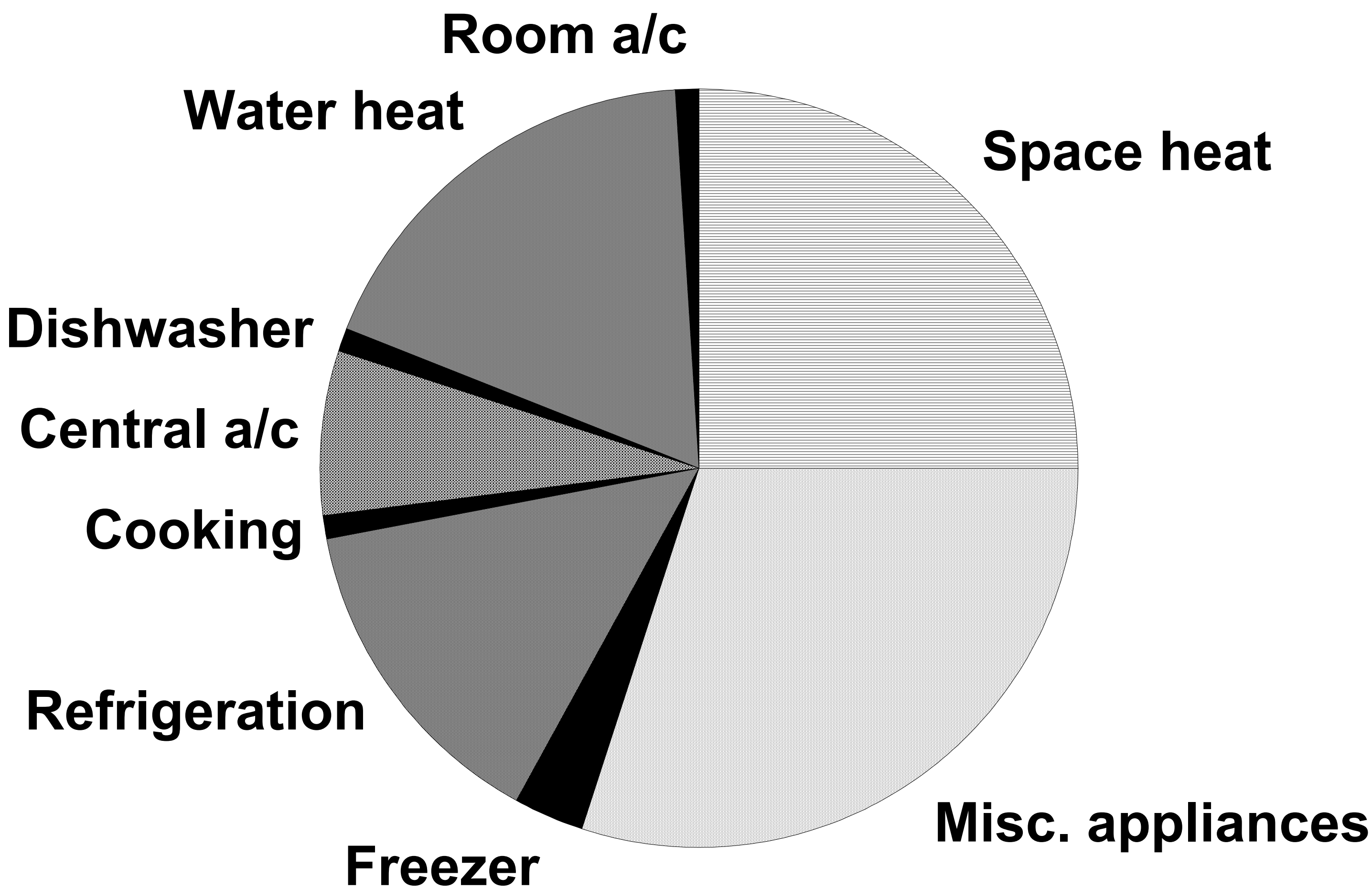
Source: EPRI CU-6746 (1990)

Potential Savings - by Sector

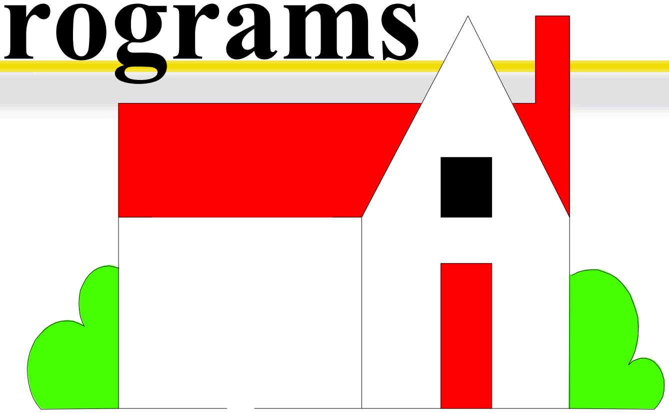


*percent of total use, year 2000

Residential Savings - by End Use

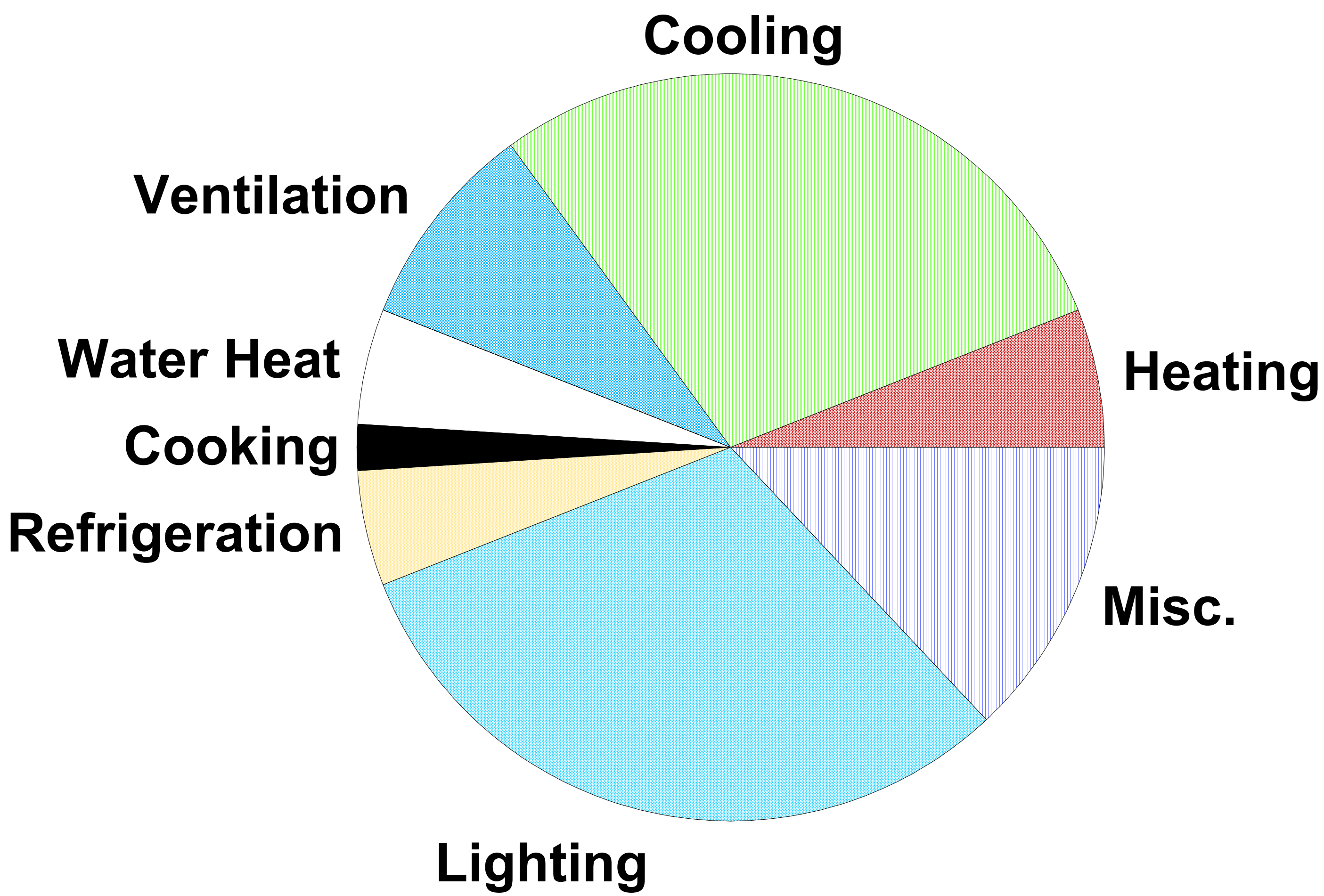


Residential Programs

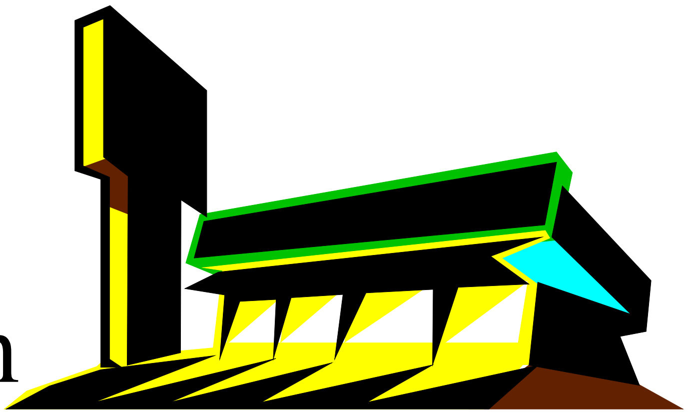


- Low-cost measures
  direct installation
- Home weatherization financing
- Low-income weatherization grants
- New construction standards*
- Manufactured housing incentives*
- Water heating efficient equipment
- Air conditioner rebates
- Used refrigerator buy-back, recycling
- Compact fluorescent incentives

Commercial Savings - by End Use

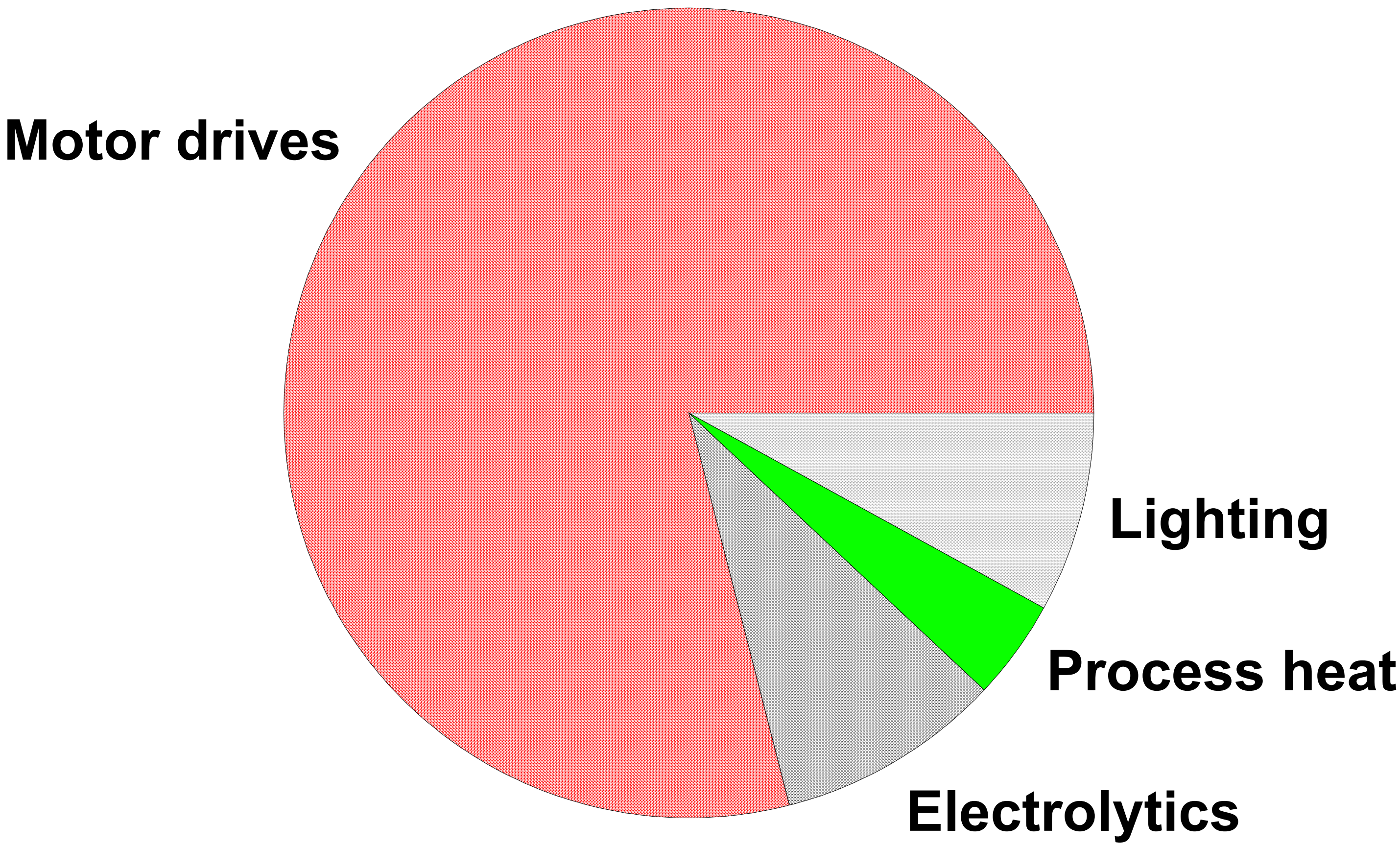


Commercial Programs



- Efficient lighting incentives (C/I)
- New construction design assistance*
- New construction building commissioning*
- Existing buildings recommissioning
- HVAC replacement rebates*
- Small commercial direct installation

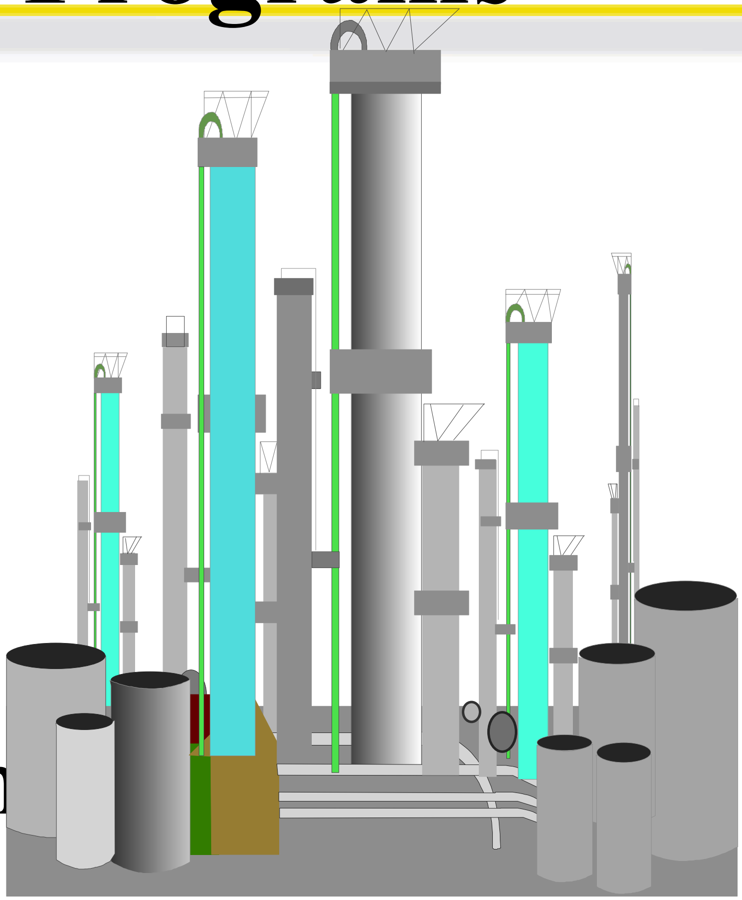
Industrial Savings - by End Use



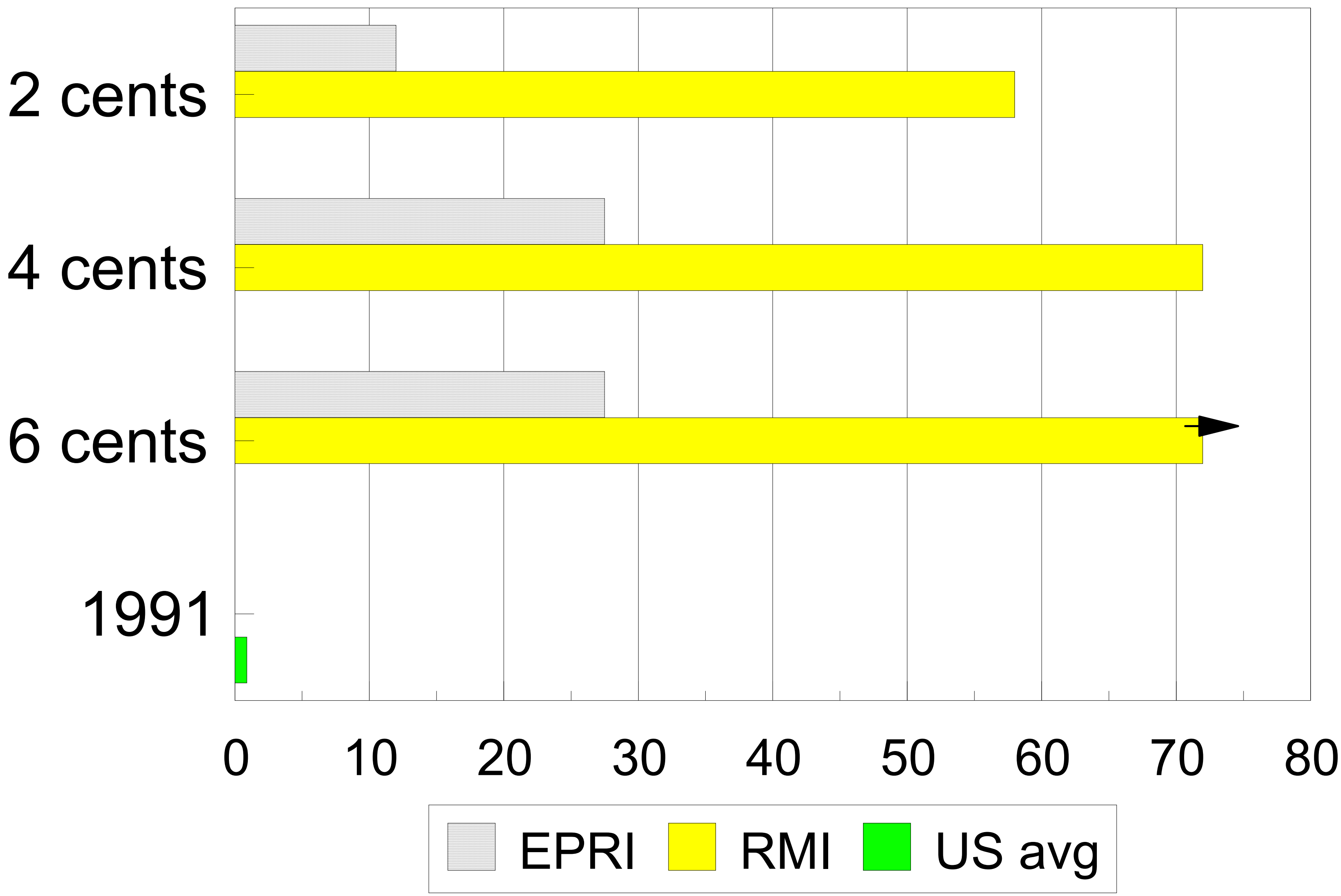
Industrial Programs

- High efficiency motors (C/I)*

- Custom process improvement incen

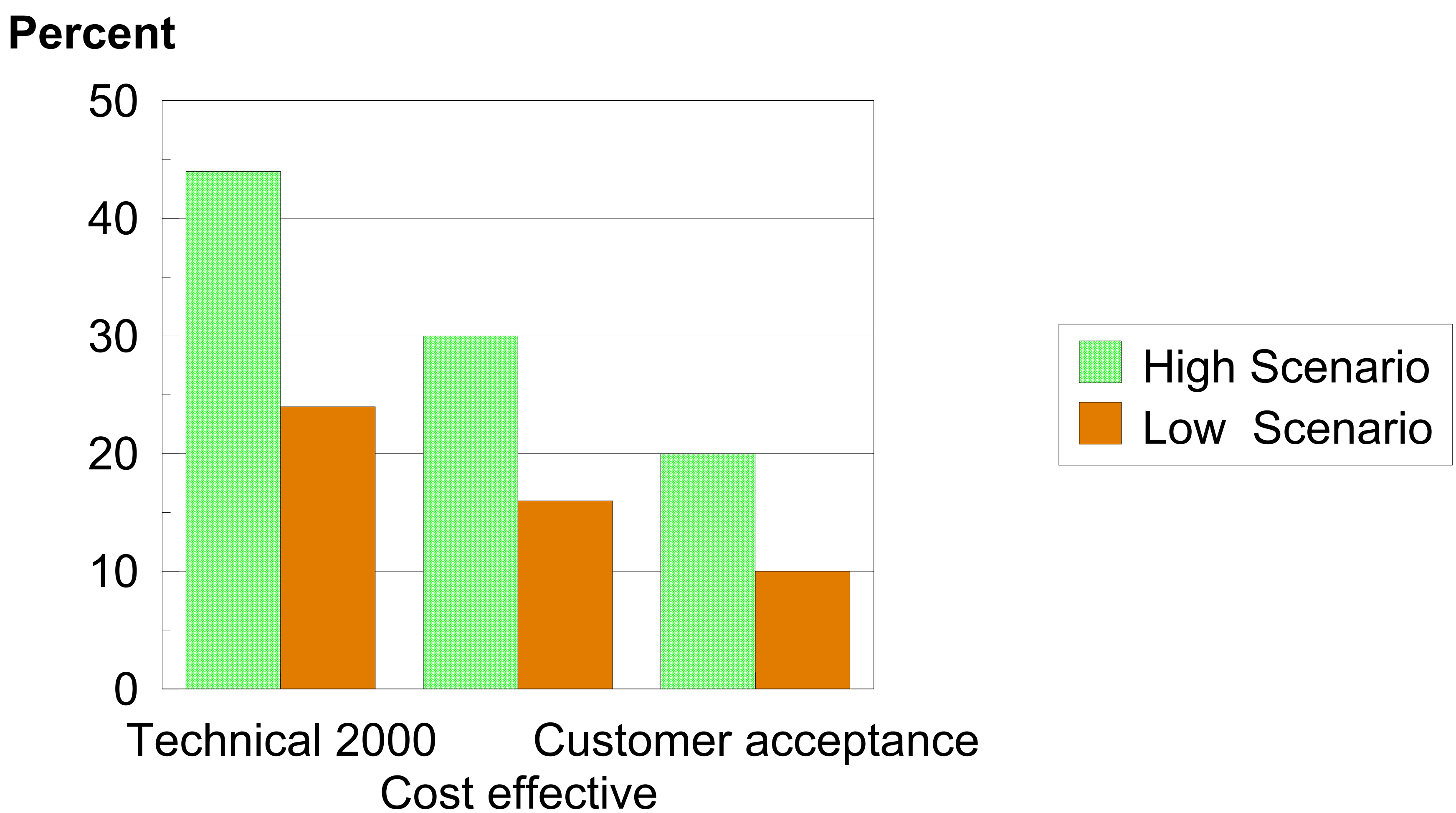


Cost-effective Savings

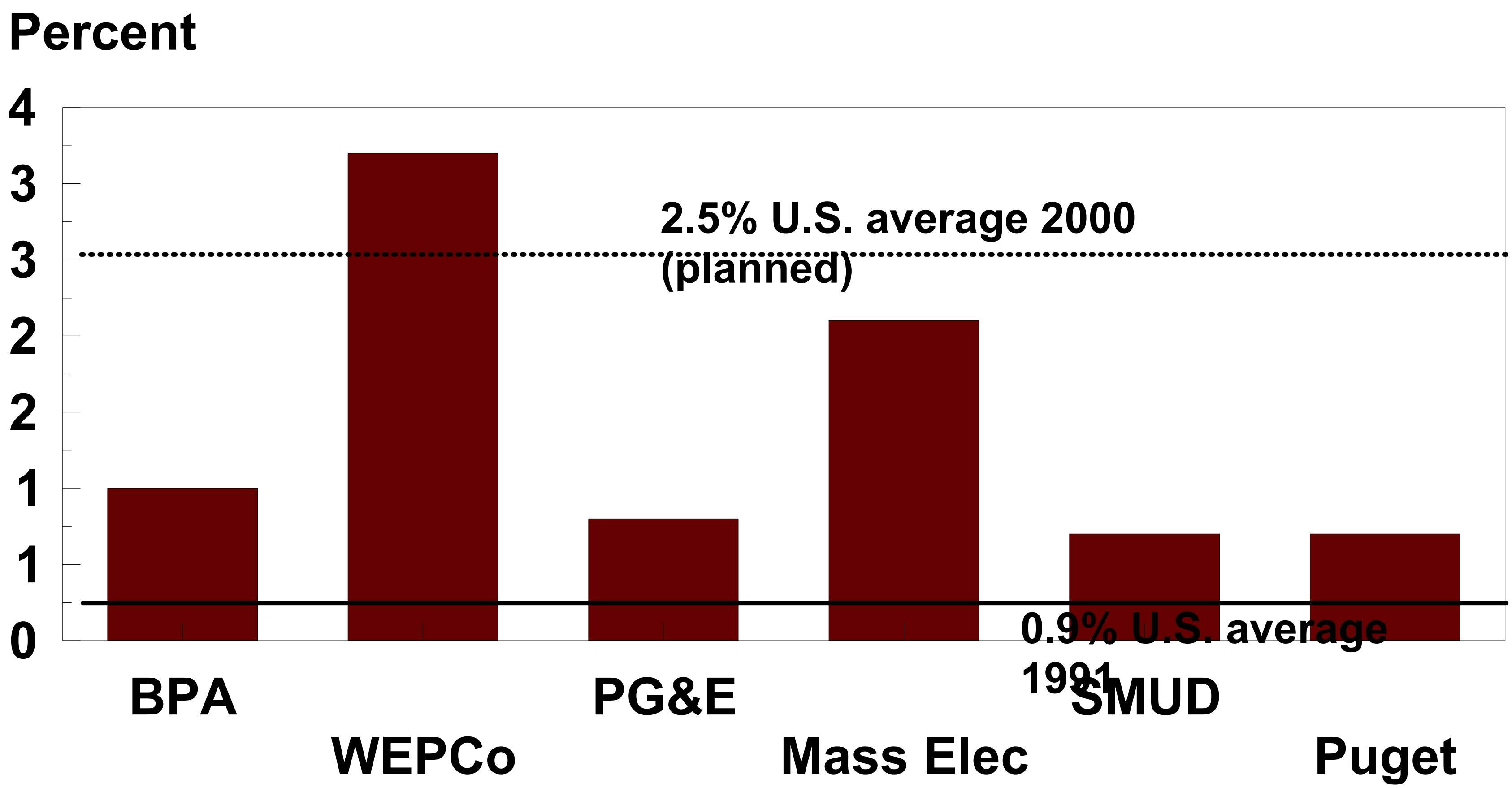


Source: Fickett, Gellings, Lovins, *SCIENTIFIC AMERICAN*, September 1990

Energy Savings Potential



1991 DSM Reduction in Total Energy

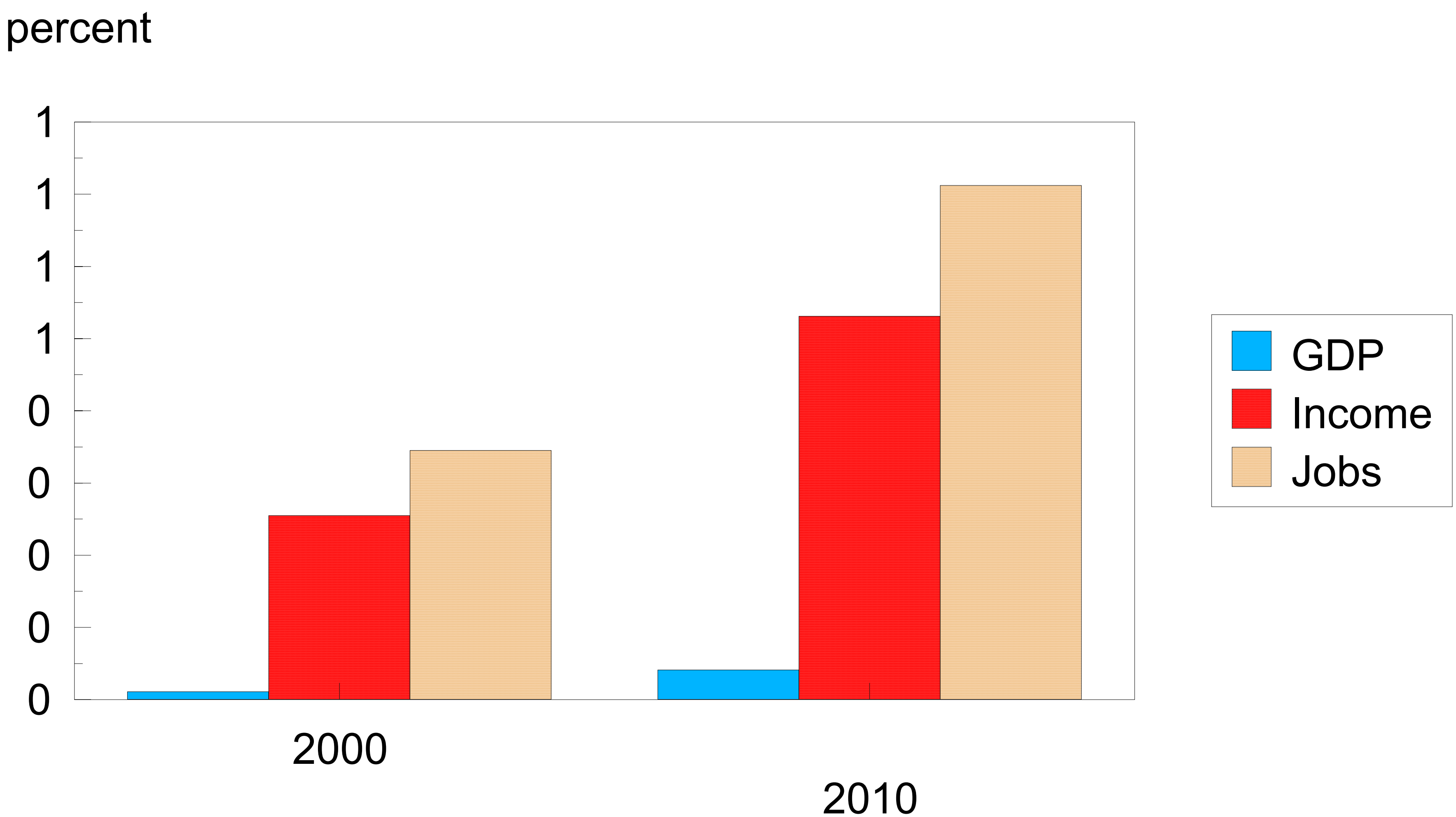


Source: Hirst, ORNL/CON-364 (1993)

DSM Programs are Adaptable

- Avoided costs
- Economic cycles
- Energy deficit or surplus
- Competition for customers

DSM Net Economic Impacts



Source: Geller, et al., ACEEE (1992)

Jobs added = 1.1 million in 2010

Conclusions

- DSM potential is large
- Opportunities exist in all sectors
- Market barriers must be overcome
- DSM is adaptable to different situations

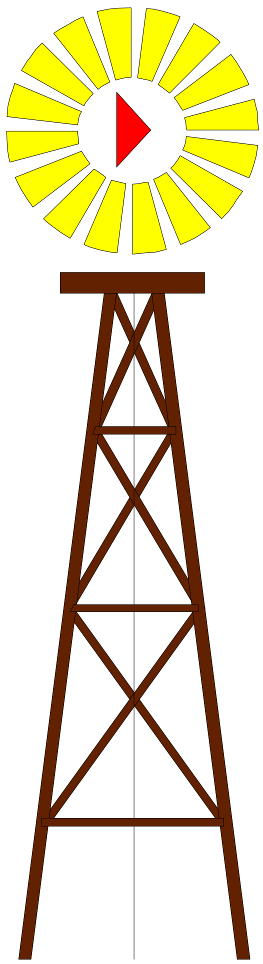
Environmental Issues

Overview

- Environmental impacts of different fuels/technologies
- Environmental pollutants
- Methods of environmental regulation
- Special problems

Environmental Impacts of Different Fuels/Technologie

- Coal
- Oil
- Natural gas
- Nuclear
- Renewables
  - wind
  - hydro
  - biomass
  - PV
- Demand-side management



Environmental Pollutants

- Air
  - NOx
  - SOx
  - Particulates
  - Greenhouse gases
- Water
- Solid waste
- Radioactive wastes

Methods of Environmental Regulation

- Health-based environmental standards for regions
- Plant-specific controls: end of the pipe emissions and technology
- Pollution prevention
- Environmental externality adders/values (avoided cost)
- Emissions trading and offsets

Special Problems

- Siting issues/politics
- Lender requirements
- Pollution control costs: old plants versus new plants
- Joint implementation
- Environmental comparability

Where IRP Intersects

- Resource cost assumptions
- Fuel cost assumptions
- Load forecast assumptions

Resource Need Decisions

- Prudence
  - Supply and demand
- Siting
- Certificate of need
- Transmission construction

Basic Principles

- Correct pricing of electricity is important
- Rate design process can be improved by aligning rate design with IRP
- Alignment can contribute to the success of a utility's IRP