Prospects for Early Deployment of Power Plants Employing Carbon Capture

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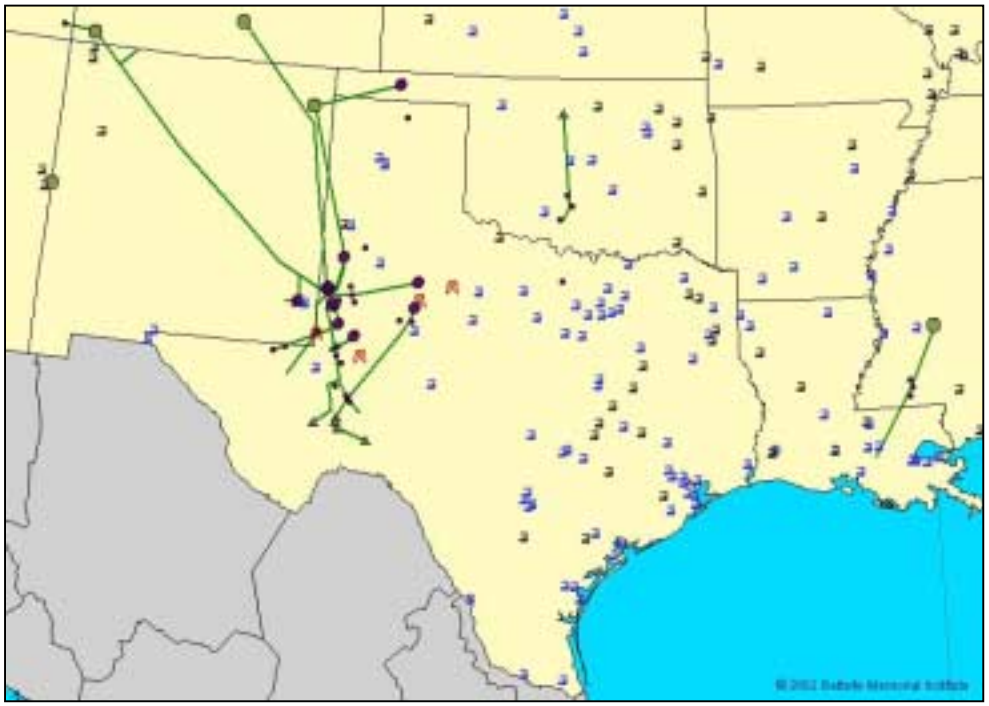
CO_2-EOR: The U.S. Landscape

- 66 Projects: > 190,000 bbl/day enhanced production
- 5 CO_2 Domes: > 1300 MMcfd, 30 TCF recoverable reserves (50+ years worth)
- Other CO_2 Sources
- CO_2 Pipeline Infrastructure

CO_2-EOR: The Permian Basin



- 47 Projects: > 155,000 bbl/day enhanced production
- 3 Domes Supplying Majority of CO_2 (> 1Bcfd)
- Gas Processing Plants Supplying Remainder
- CO_2 Pipeline Infrastructure (1900+ Miles)

CO_2-EOR: California Prospects

- Many experts believe next largest opportunity outside Permian Basin
- CO_2 Demand Estimate: 3-5 Tcf
- Mature Fields in San Joaquin and Los Angeles Basins
- Pilot Study On-Going
- Success Could Lead to Recovery of Billions of Barrels of Trapped Oil

Some Risks in Building and Operating Electric Power Generators

- **Technical Risk**
  - Construction cost overrun
  - Delay in start up
  - Equipment fails to achieve design performance
  - Unscheduled down time
- **Regulatory Risk**
  - Construction permits delayed/denied
  - Operating permits delayed/redefined
  - Emission standards tightened
- **Supply Risk**
  - Price increase for fuel, etc.
- **Market Risk**
  - Reduced demand/reduced selling price of products

Cost & Performance Data for Fossil Generators

Technology	Thermal Efficiency, HHV, %	Carbon Emissions, kg CO2/kWh	Total Plant Cost, $/kW	LCOE @ 80% cf, Mills/kWh
NGCC-H	53.6	0.338	496	30.7
NGCC-H	43.3	0.04	943	48.8
90% capture				
IGCC-H	43.1	0.718	1263	45.1
IGCC-H	37.0	0.073	1642	56.4
90% capture				
Source: "Evaluation of Fossil Fuel Power Plants with CO2 Removal," EPRI, 2000				
http://www.netl.doe.gov/product/power1/gasification/30_publications.htm				

Study Methodology

- **Fossil generators practicing capture & sequestration commercial in 2010.**
- **Plant book life 20 years.**
- ***"AEO2002"* NEMS output to estimate expected prices in California *(or a region that includes CA)***
  - Price of electricity received by generators
  - Price of natural gas to generators
  - Price of coal to generators
  - Price of World Oil (determines value of CO_2 based on linear correlation developed for Permian basin)

Study Methodology (2)

- **Historic data for prices to estimate variability (standard deviation) in 2010-2030.**
- **Expressions for Required Selling Price of Electricity (RSPOE) for**
  - NGCC
  - NGCC+S
  - IGCC+S
- **Cost components of RSPOE**
  - Fixed O&M
  - Var. O&M
  - Consumables
  - Byproduct credit including CO_2
  - Fuel
  - Capital charges

Study Methodology (3)

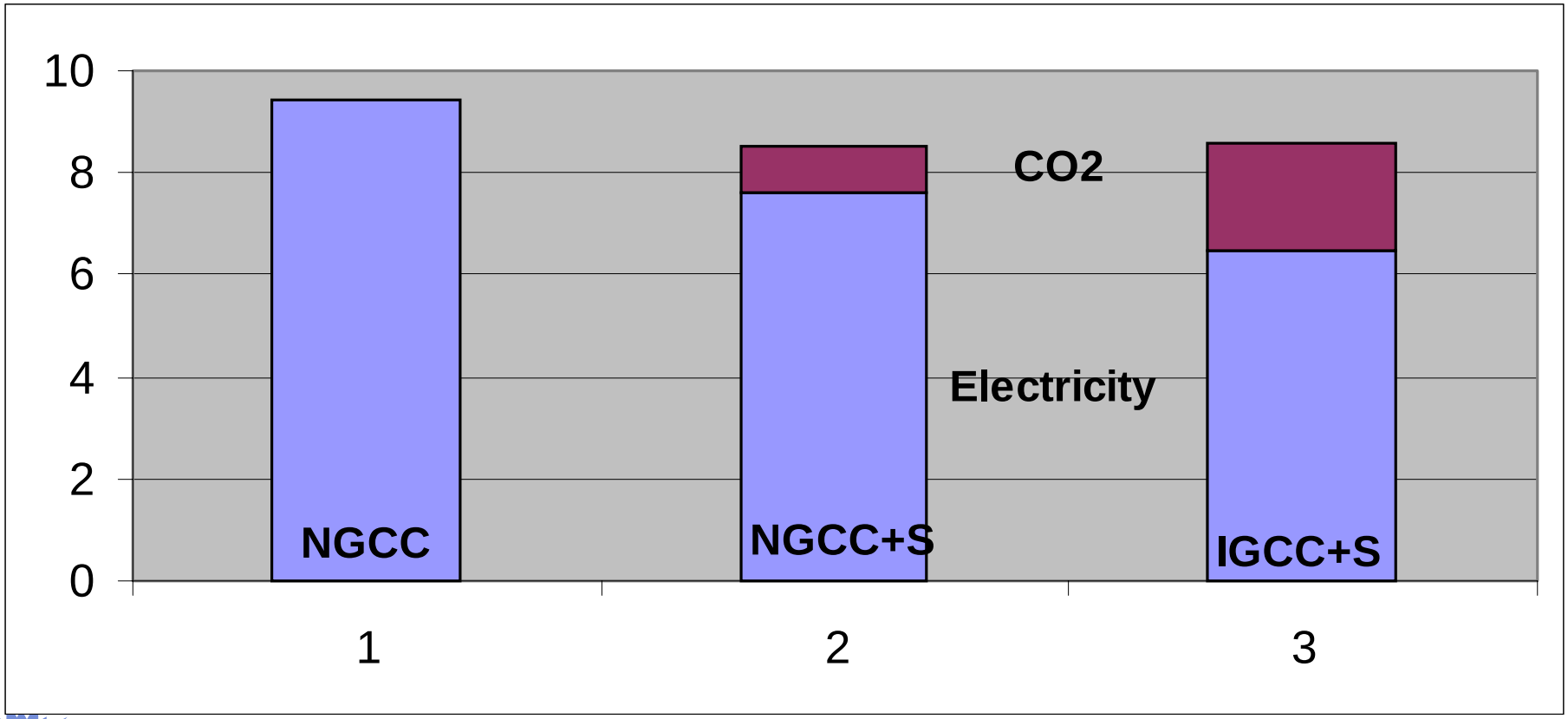
- In expressions for RSPOE, fuel costs and CO_2 value are probabilistic variables.
- In expressions for Return on Common Stock Equity, RSPOE and price of electricity received by generators are probabilistic variables.
- All prices expressed as constant year 2000 dollars and cents.

Capital Structure for Plant Investment

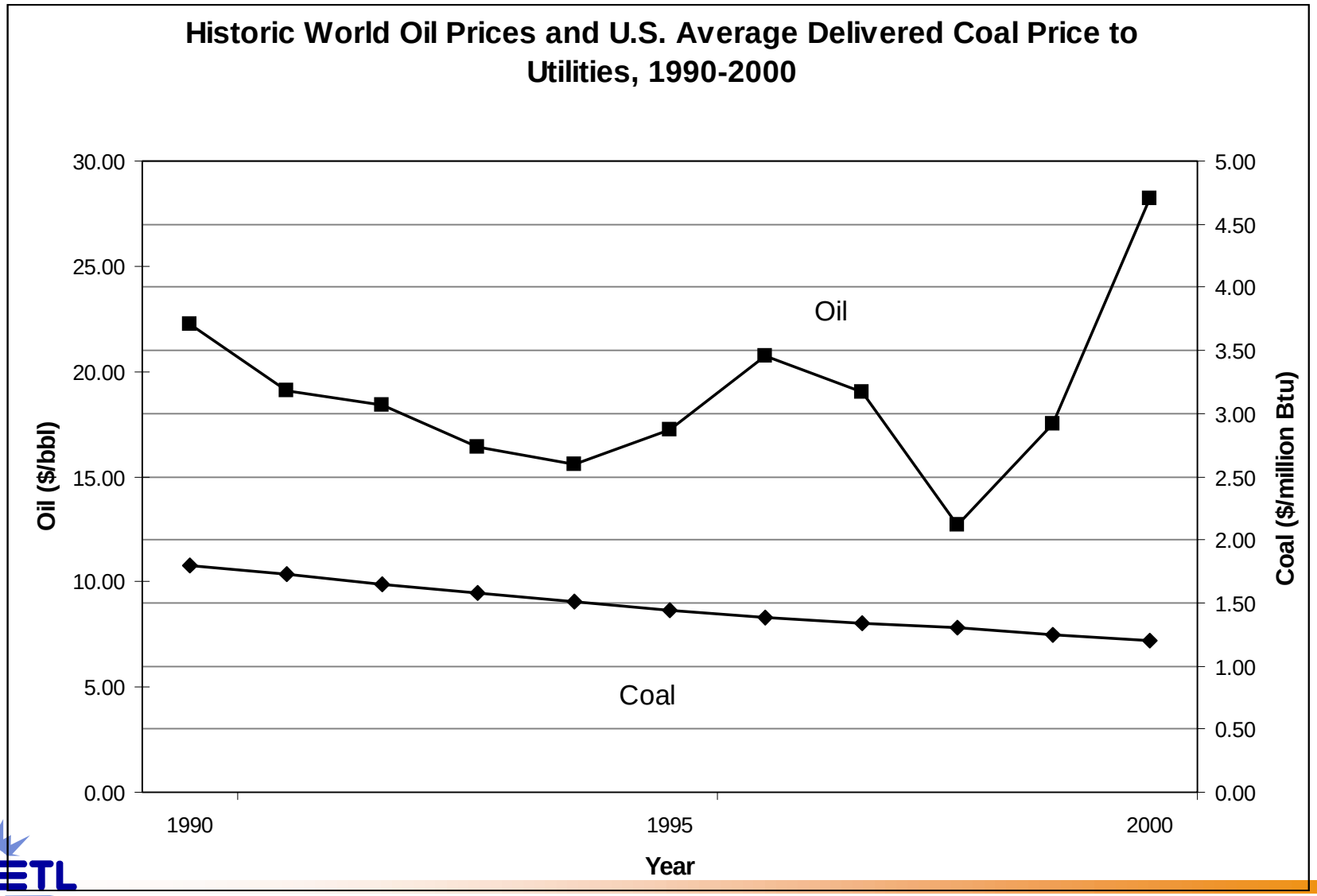
	Percent of Total	Rate of Return	
		Current $	Constant $
Debt	45	9	5.83
Pref. Stock	10	8.5	5.34
Com. Stock	45	12	8.74
Total	100		

Typical Product Revenue per Million Btu Fuel Consumption, Dollars

(6 cent/kWh electricity, $19/tonne CO_2, or $1.00/Mcf)



Historic Prices Used to Estimate Variability



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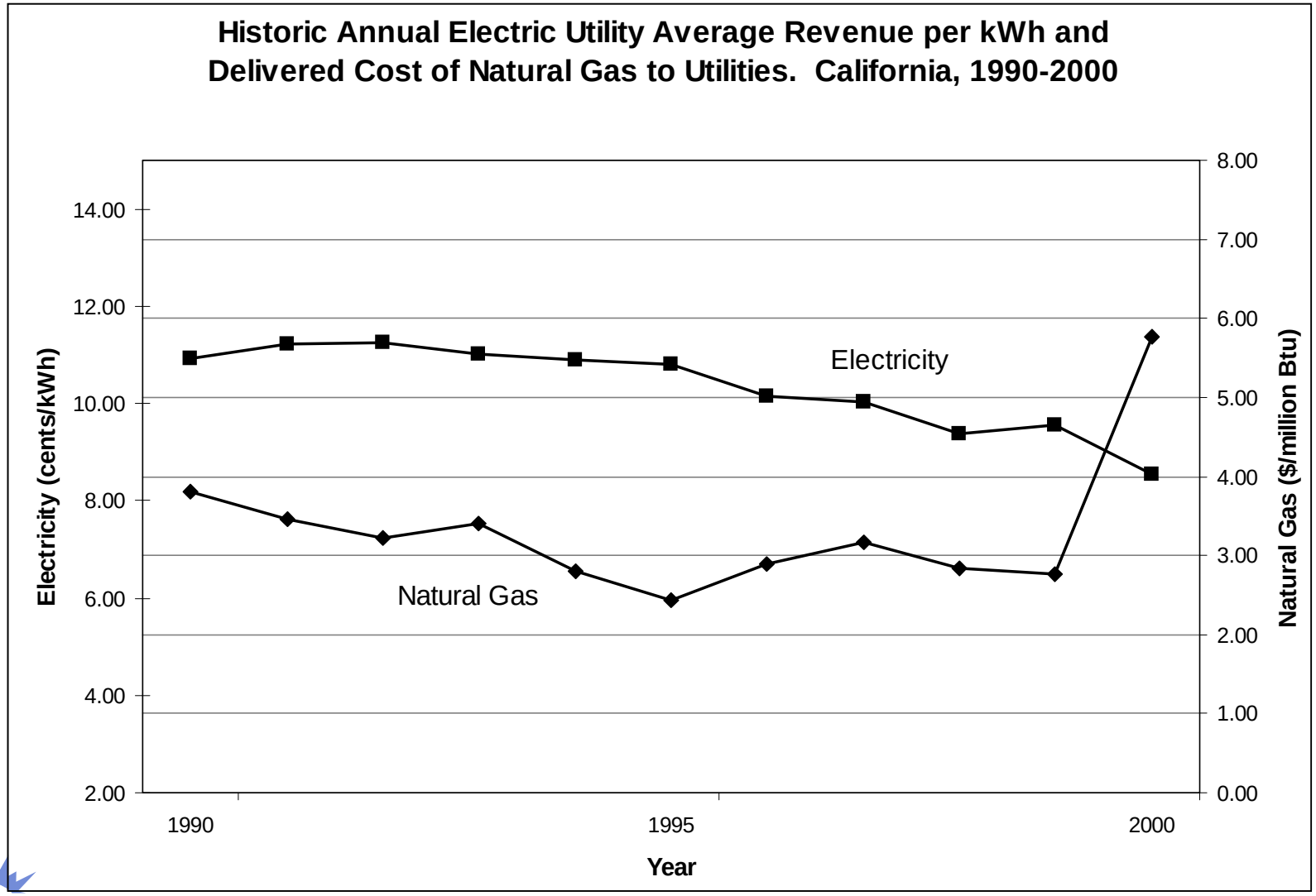
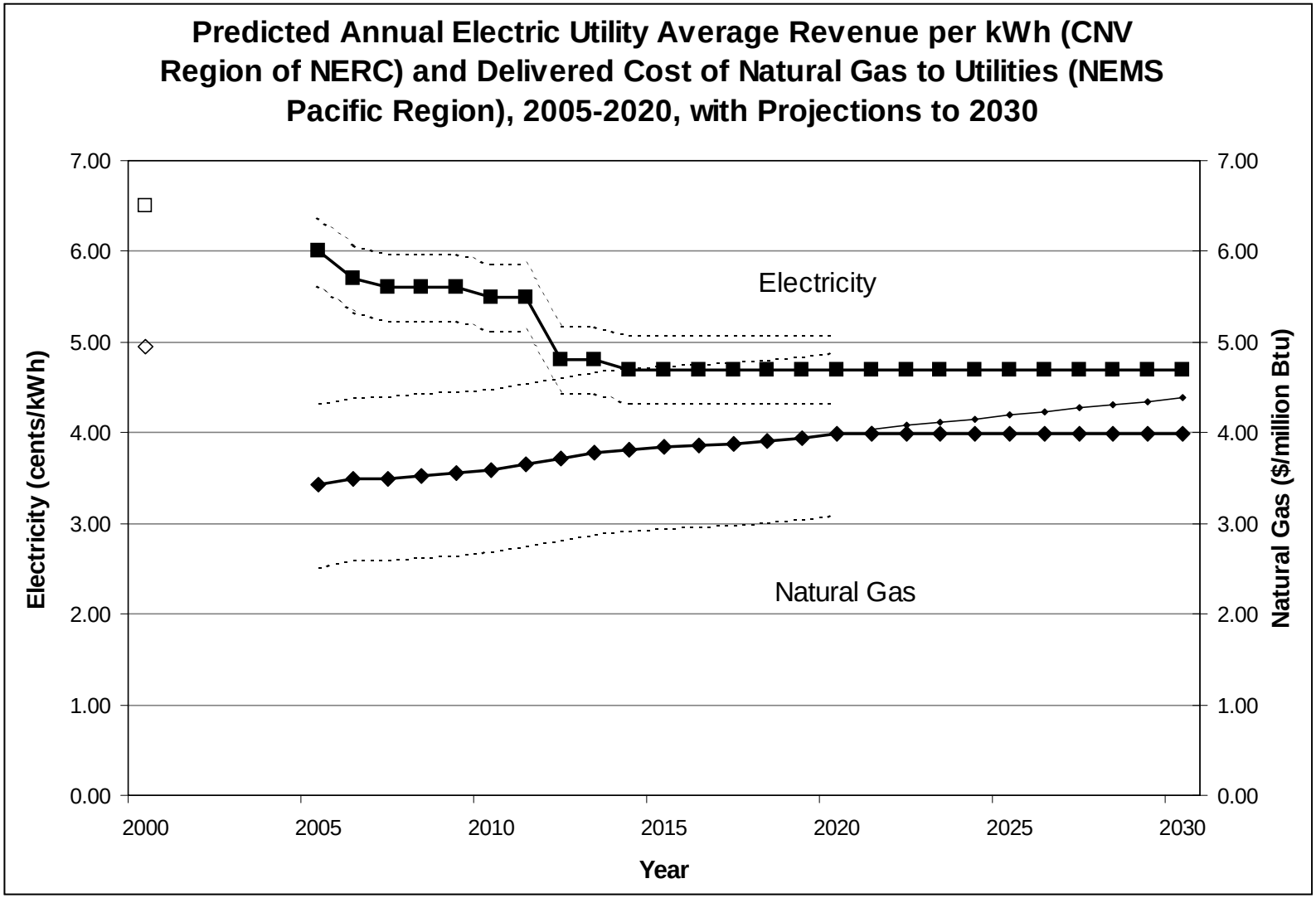


Price Variability, 1990-2000

Price	Data Set	Std. Dev.
Nat. Gas	Deliv. Cost to CA Utilities	$0.90/mill. btu
Coal	Deliv. Cost to U.S. Utilities	$0.024/mill. Btu
Oil	World Oil	$4.03/bbl
Electricity	Avg. Revenue to CA Generators	0.37 cent/kWh

Predicted Prices with Std. Devs.



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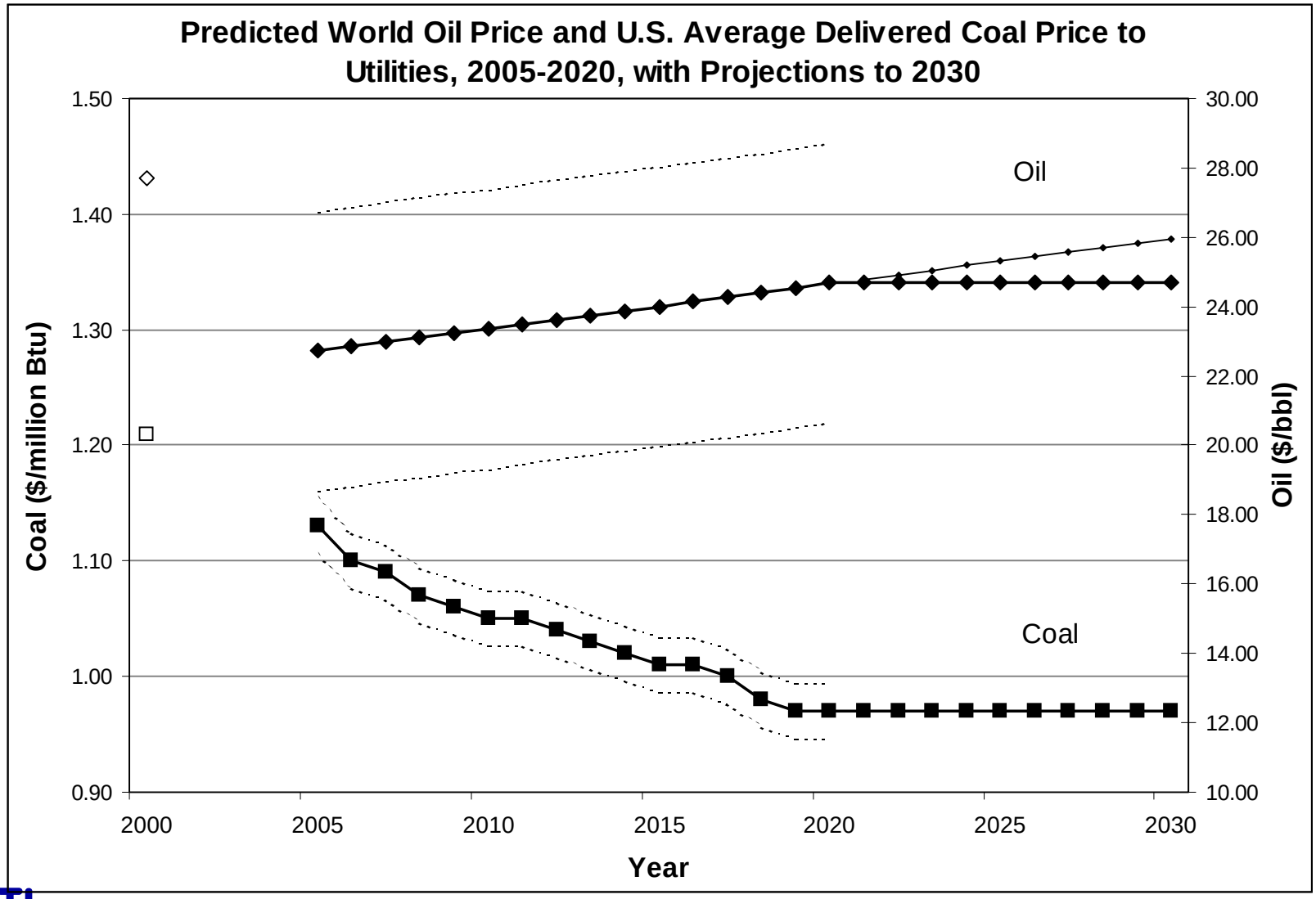
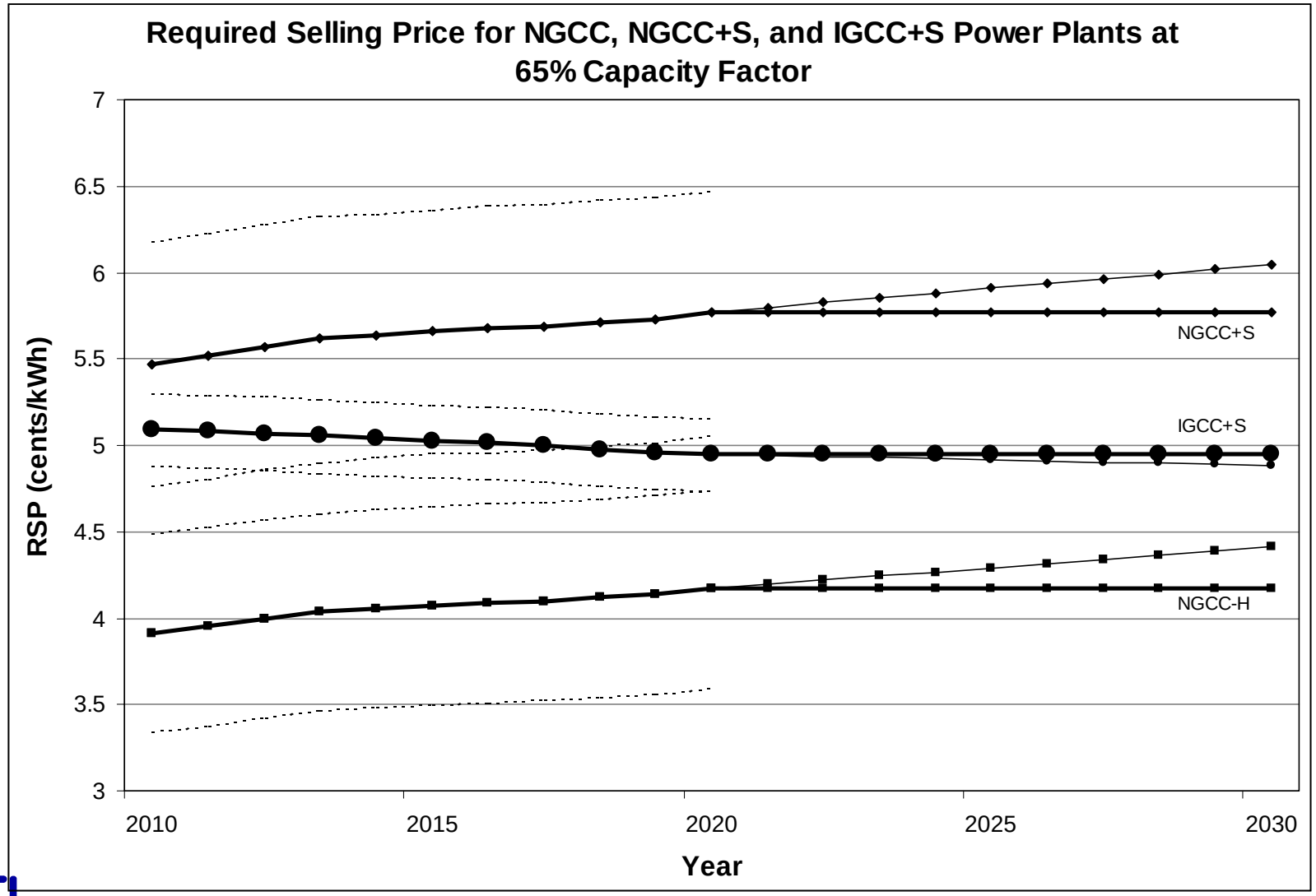


Predicted Required Selling Prices of Electricity with Std. Devs.



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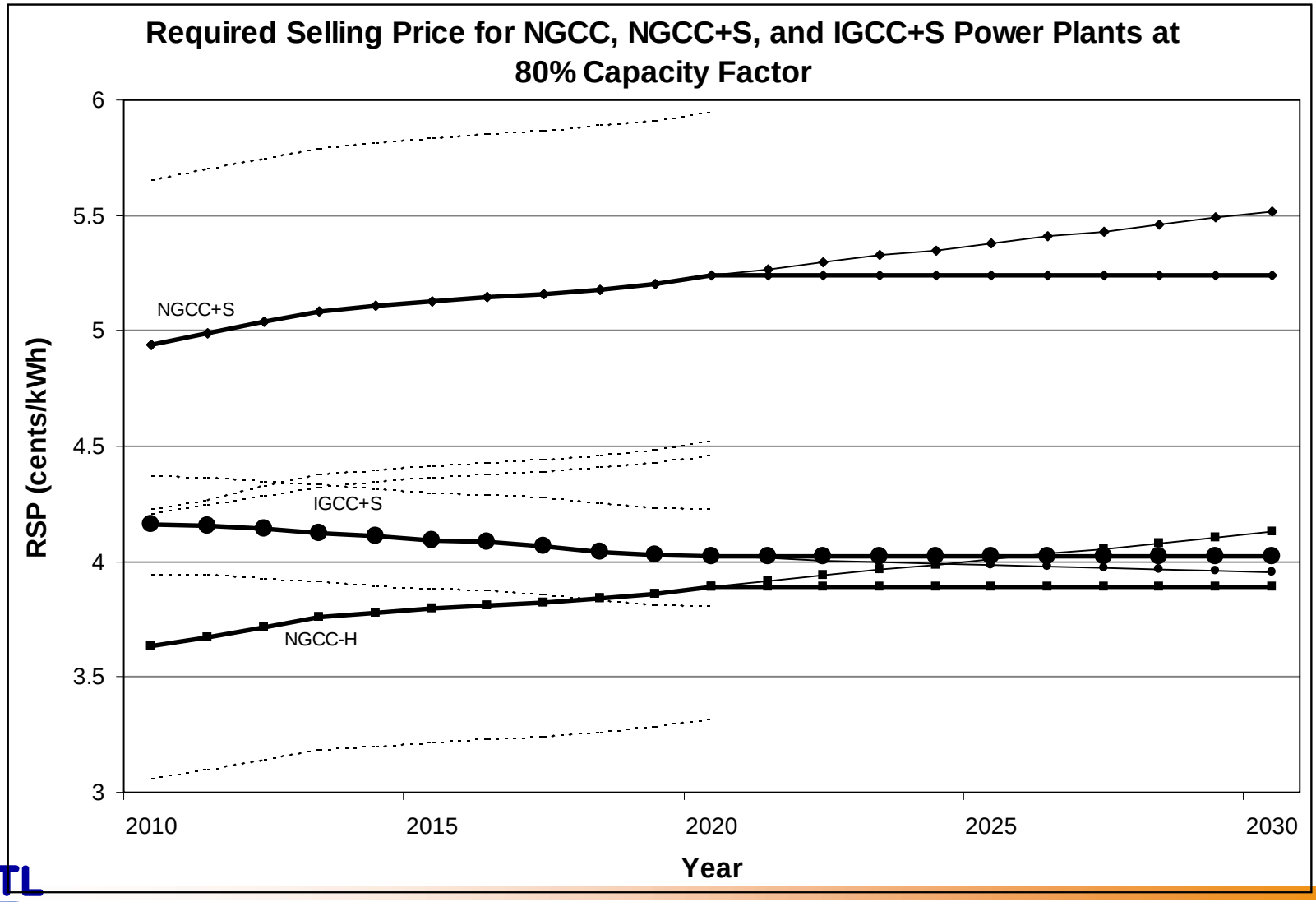
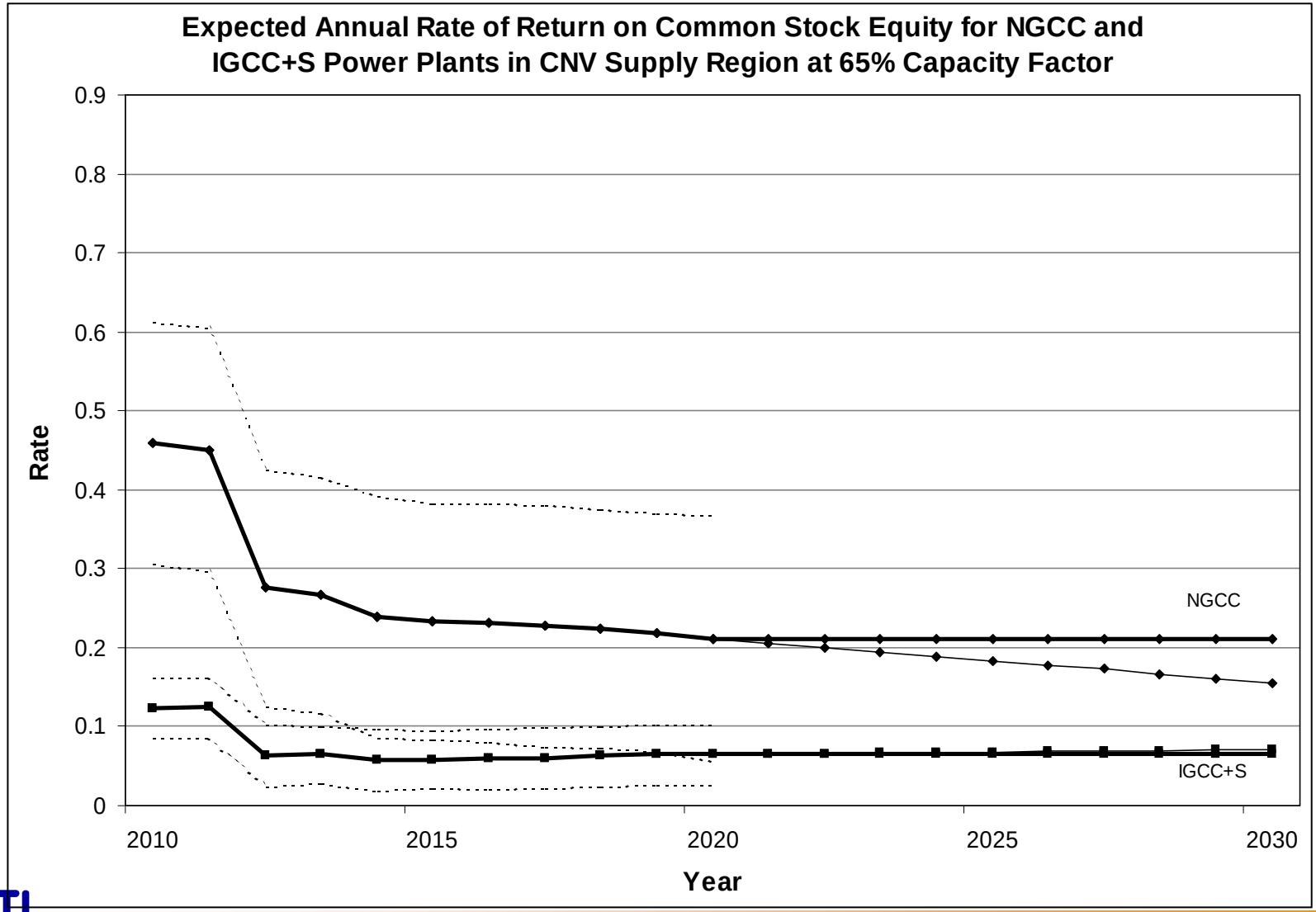


Predicted Return on Common Stock



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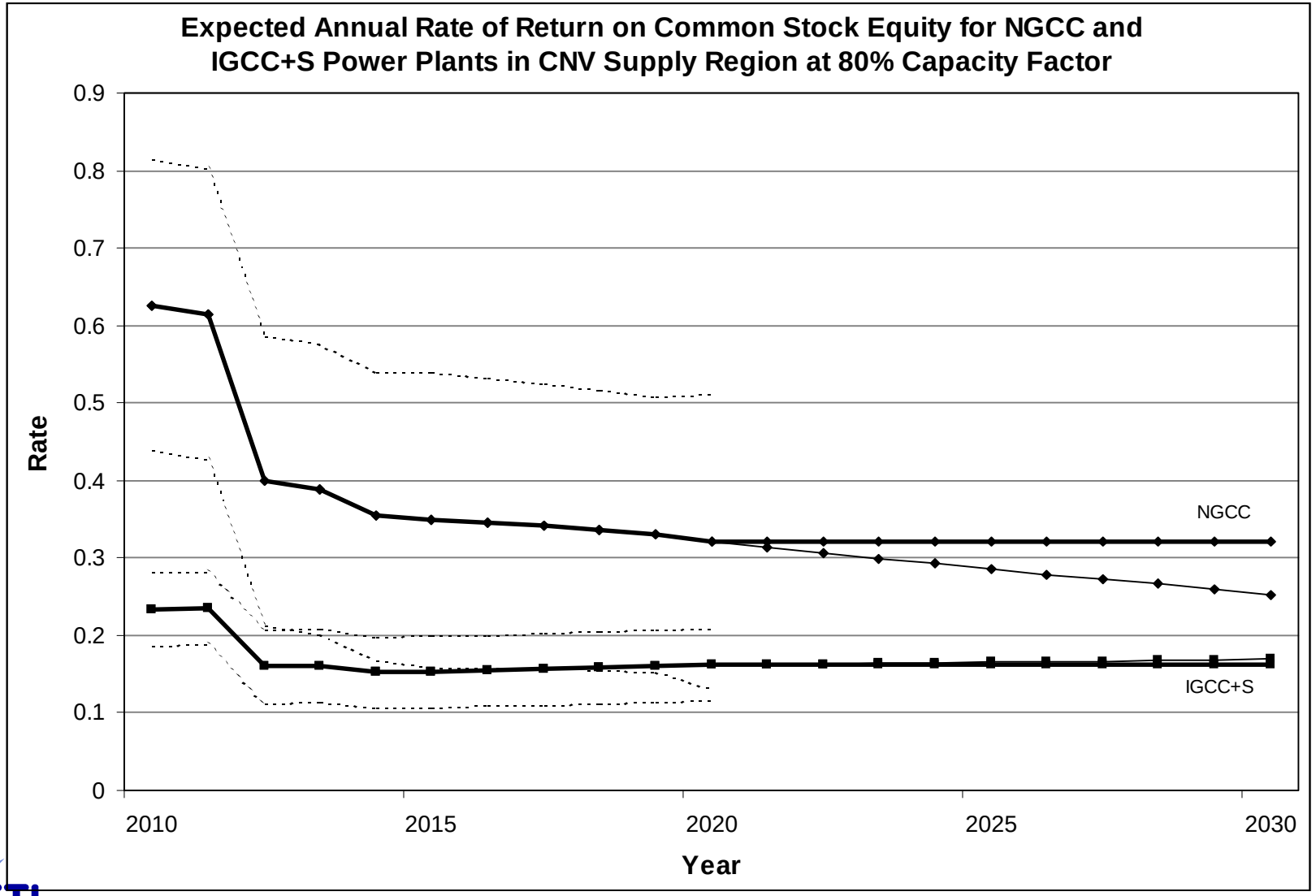

Results

- When there is a market for CO_2, IGCC+S is profitable without regulatory incentive for carbon capture.
- NGCC has lowest RSPOE and highest return on investment over entire period.
- NGCC+S has highest RSPOE and greatest uncertainty in RSPOE, i.e. it is Weakest Link.
- Use of expected prices specific to CA could change results, probably in favor of IGCC+S.
- Standard deviation of RSPOE for NGCC three times larger than for IGCC+S.
- Probability of negative return on common stock greater for NGCC than for IGCC+S.