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September 27th, 2012

MEMORANDUM

TO: Power Committee

FROM: Ken Corum

SUBJECT: A primer on carbon emissions

Carbon emissions were a significant factor in the 5th and 6th Power Plans, and can be expected to be a significant factor again in the 7th Plan. They are perhaps the greatest source of environmental uncertainty the Council will need to deal with in the 7th Plan.

In the 6th Plan, carbon (together with other greenhouse gasses) was treated as a risk, based in part on the national policy debate that was underway as the Council developed the plan. The “cap and trade” system that was receiving the most attention at the time was not adopted, but the Environmental Protection Agency is now working on the development of regulation of carbon emissions. In addition to reflecting the financial risk of regulation and carbon cost in the Council’s Plan, the Council is also required to consider environmental costs more broadly.

This presentation is intended to provide a foundation of facts from which discussion of the issue can proceed as we move into the preparation of the 7th Plan.

Carbon Emissions Primer

Power Committee

October 9, 2012

Whitefish, MT

CO2 Content by Fuel

(lbs CO2 per MMBtu of Fuel)

- **Coal (subbituminous) 212.7**
- **Natural gas 117.1**



Fuel Conversion Efficiencies

(MMBtu of Fuel per MWh of Power)

- **Coal-fired generation**
 - Conventional (existing PNW fleet) 10.70

- **Natural gas-fired generation**
 - Combined-cycle combustion turbine 6.93
 - Single-cycle combustion turbine 9.37
 - Large reciprocating engine 8.85



Emissions by Generation Type

(lbs CO₂ per MWh of Power)

- **Coal-fired generation**
 - **Conventional (existing PNW fleet)** **2,277**

- **Natural gas-fired generation**
 - **Combined-cycle combustion turbine** **812**
 - **Single-cycle combustion turbine** **1,097**
 - **Large reciprocating engine** **1,036**

CO2 Costs by Generation Type (\$/MWh)

CO2 Tax or Price

\$10/ \$40/
tonne tonne

■ Coal-fired generation

- Conventional (existing PNW fleet) \$10.33 \$41.30

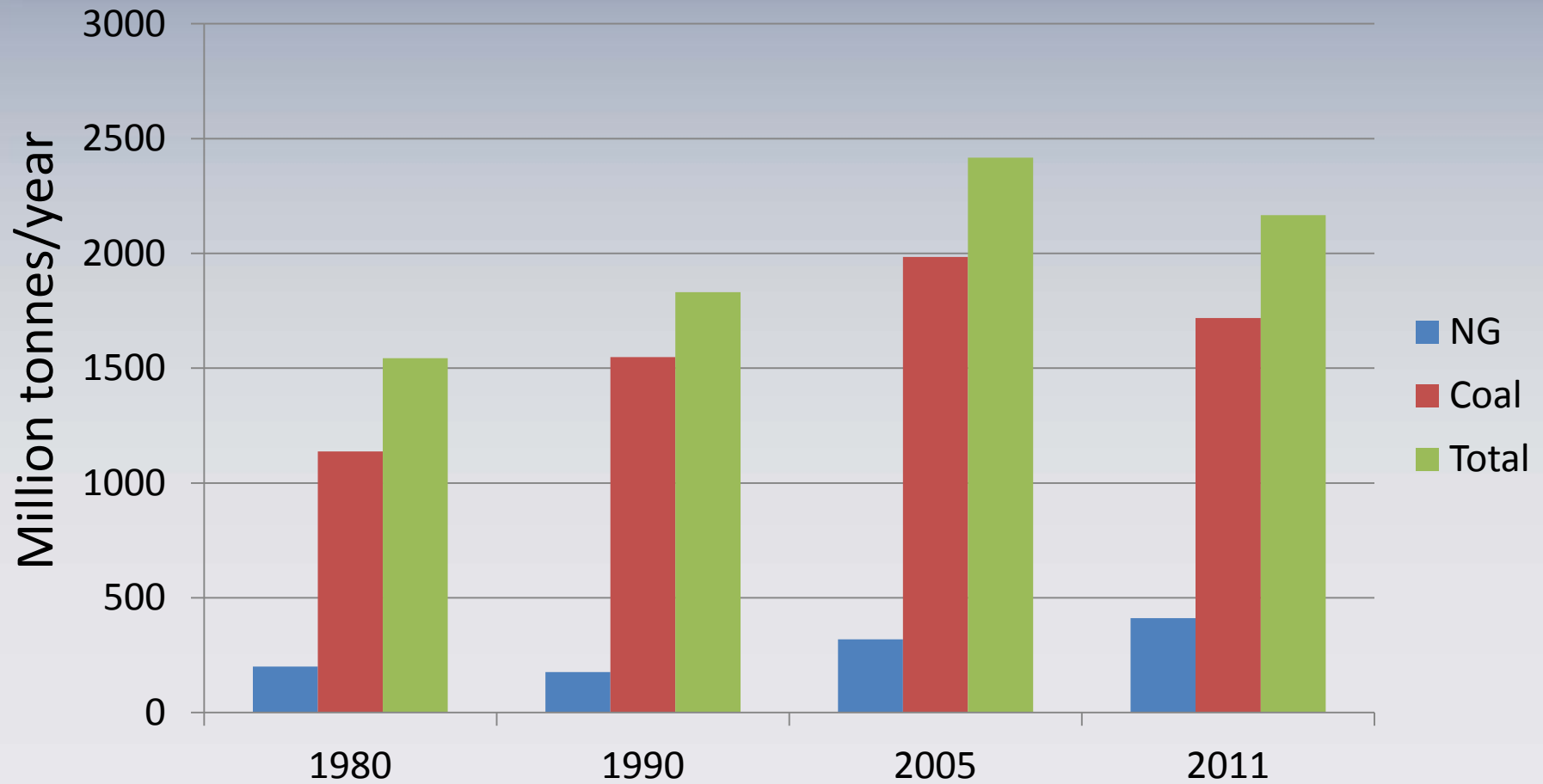
■ Natural gas-fired generation

- Combined-cycle combustion turbine \$3.68 \$14.73
- Single-cycle combustion turbine \$4.98 \$19.91
- Large reciprocating engine \$4.70 \$18.81

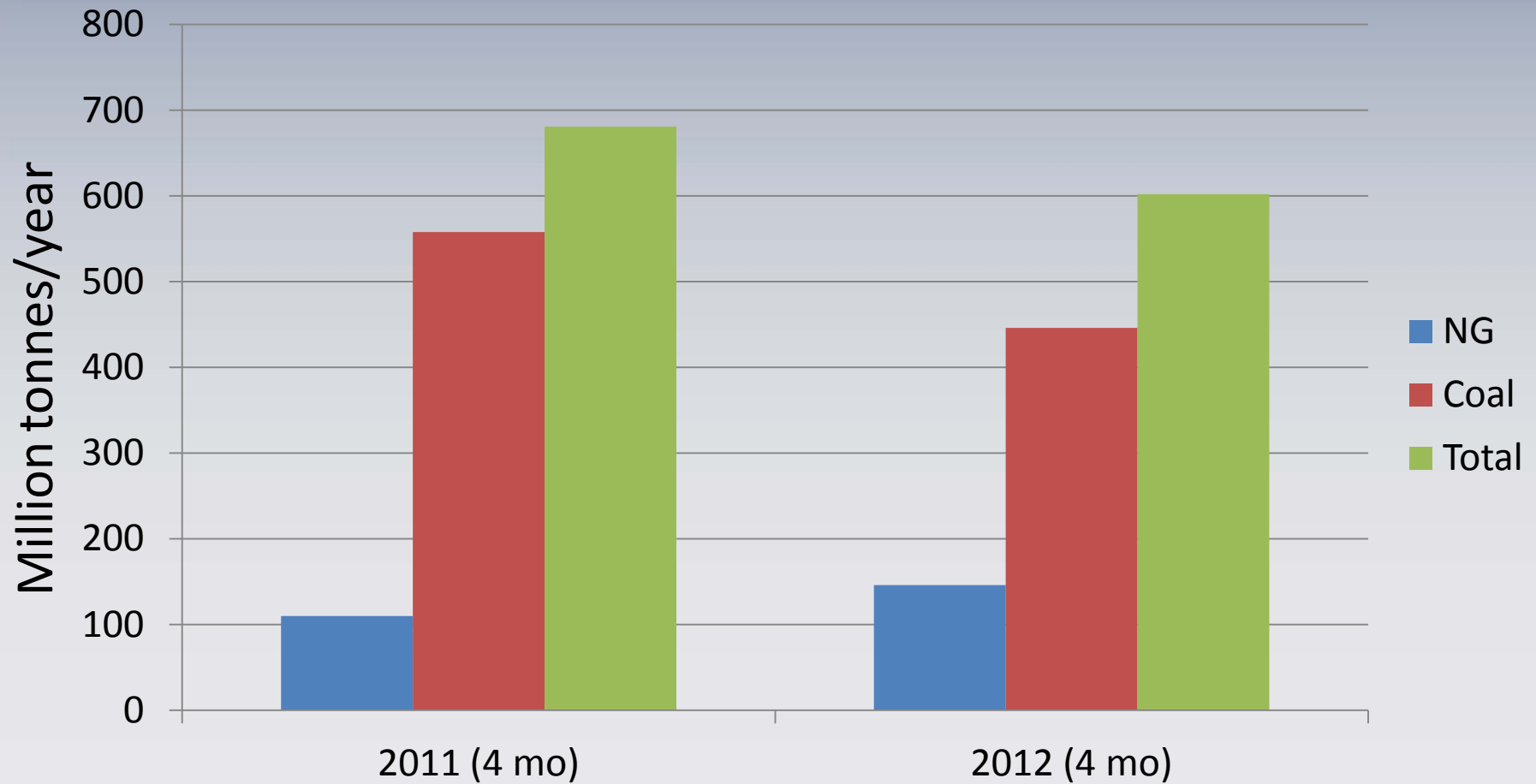
Regulatory Approaches to Reduce CO2 Emissions

- Mandates (e.g., emissions performance standards, renewable portfolio standards)
 - Simple, somewhat inflexible
- Carbon taxes
 - Use market forces to achieve compliance
 - Costs are known, effects are uncertain
- Cap and trade programs
 - Use market forces to achieve compliance
 - Effects are known, costs are uncertain

National CO2 Emissions (Electric Power Sector)



National CO2 Emissions (Electric Power Sector)



Forces Driving the Reduction in CO₂ Emissions

- Energy intensity of economy is decreasing
 - Product mix
 - Energy efficiency
- Recession?
 - GDP in 2011 was 5.6% higher than 2005

Forces Driving the Reduction in CO₂ Emissions

- Power plant dispatch costs have shifted – natural gas is now competitive with coal
 - Lower natural prices
 - Higher coal prices (coal growing as export commodity)

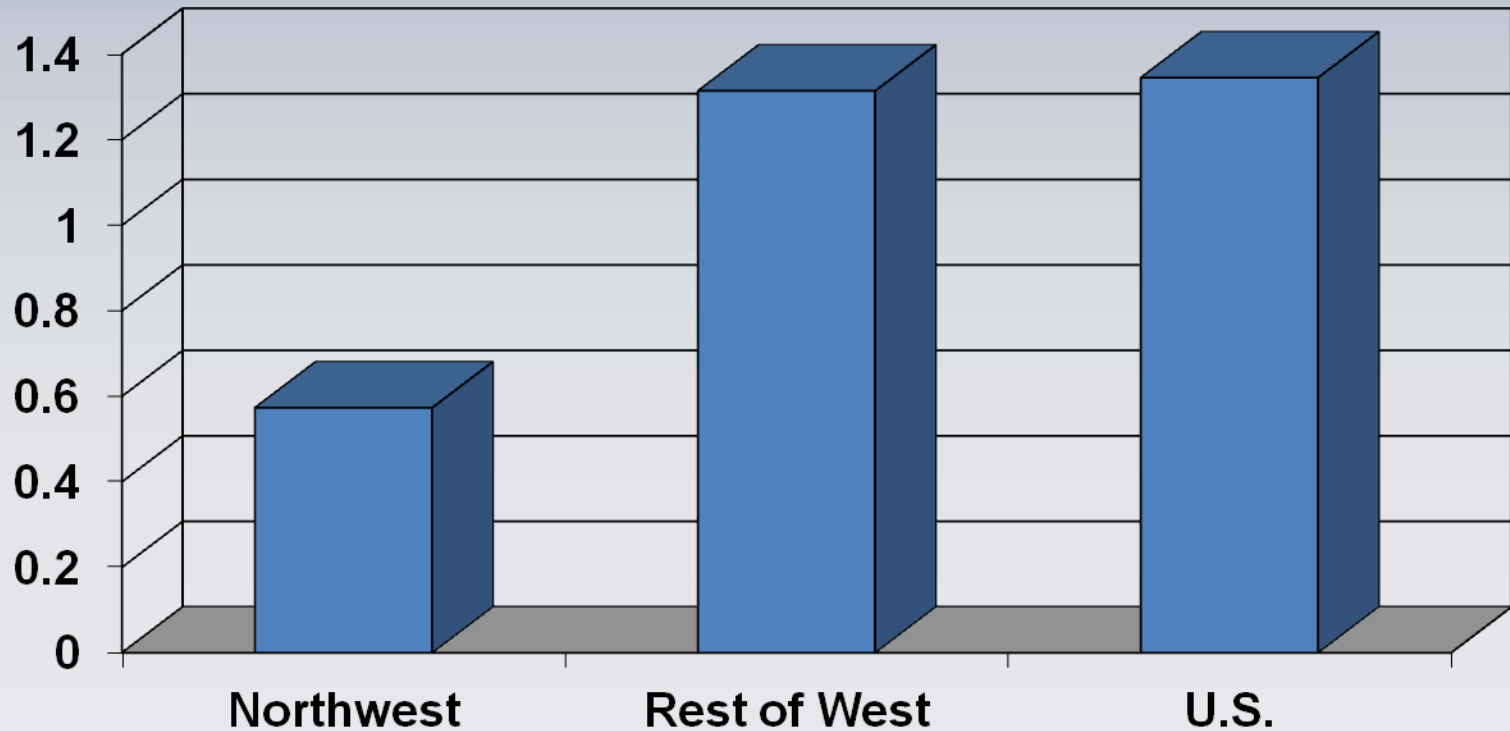
- Coal plant retirements
 - State emissions performance standards
 - More stringent regulation of non-CO₂ emissions
 - Aging coal fleet, needs for refurbishment

The U.S. Coal Fleet Is Aging

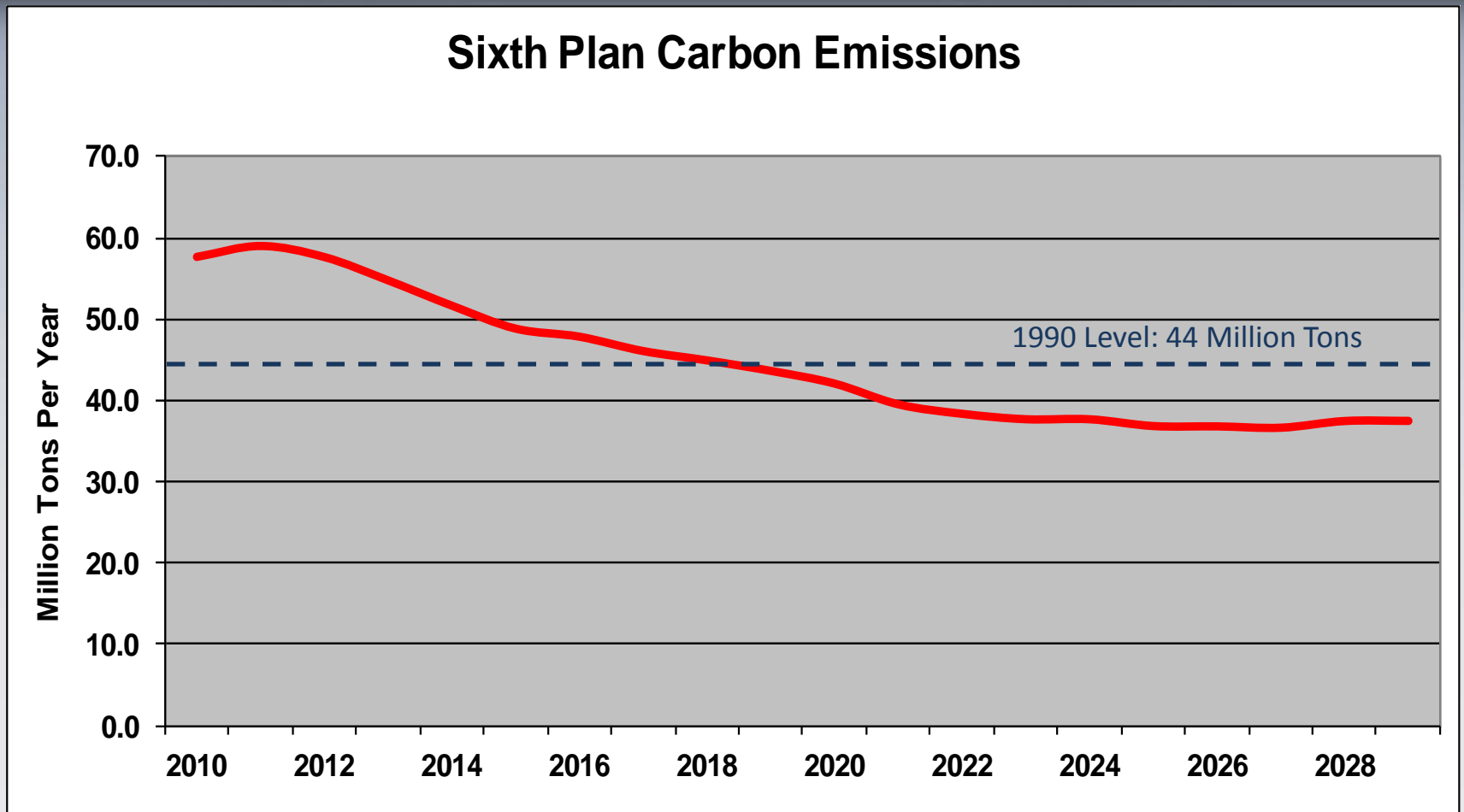
- **75% of nameplate capacity > 30 years old**
- **50% of nameplate capacity > 37 years old**
- **40% of nameplate capacity > 40 years old**

Carbon Intensity of the Northwest Power System is Low

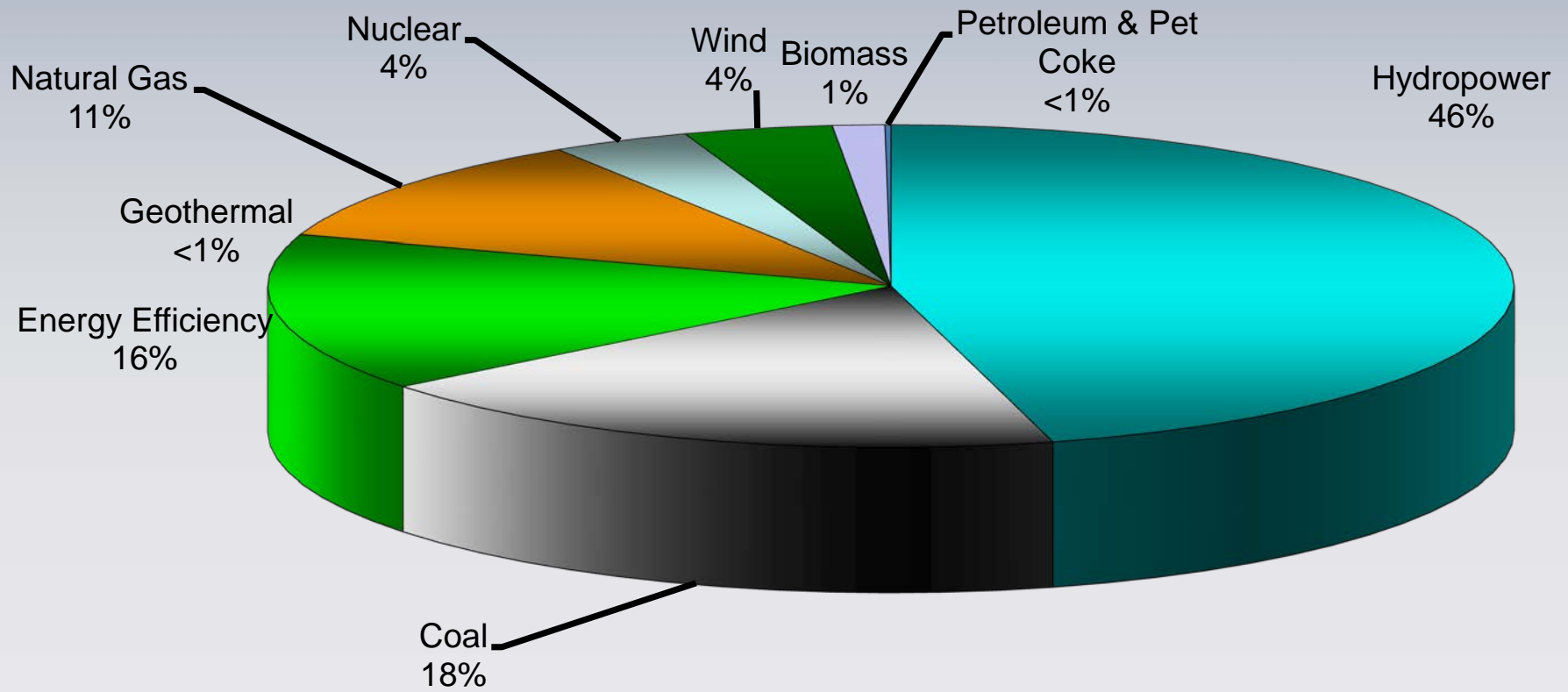
Pounds of CO2 Per kWh



...and Becoming More So



Coal is Becoming a Smaller Share of Northwest Power Resources



Does not reflect announced coal plant closures

Announced Coal Plant Retirements in the Northwest

- **Centralia: 2 x 670 megawatt units**
 - First unit closure 2020
 - Second unit closure 2025
- **Boardman: 550 megawatts**
 - Closure 2020

CO2 Cost Estimates

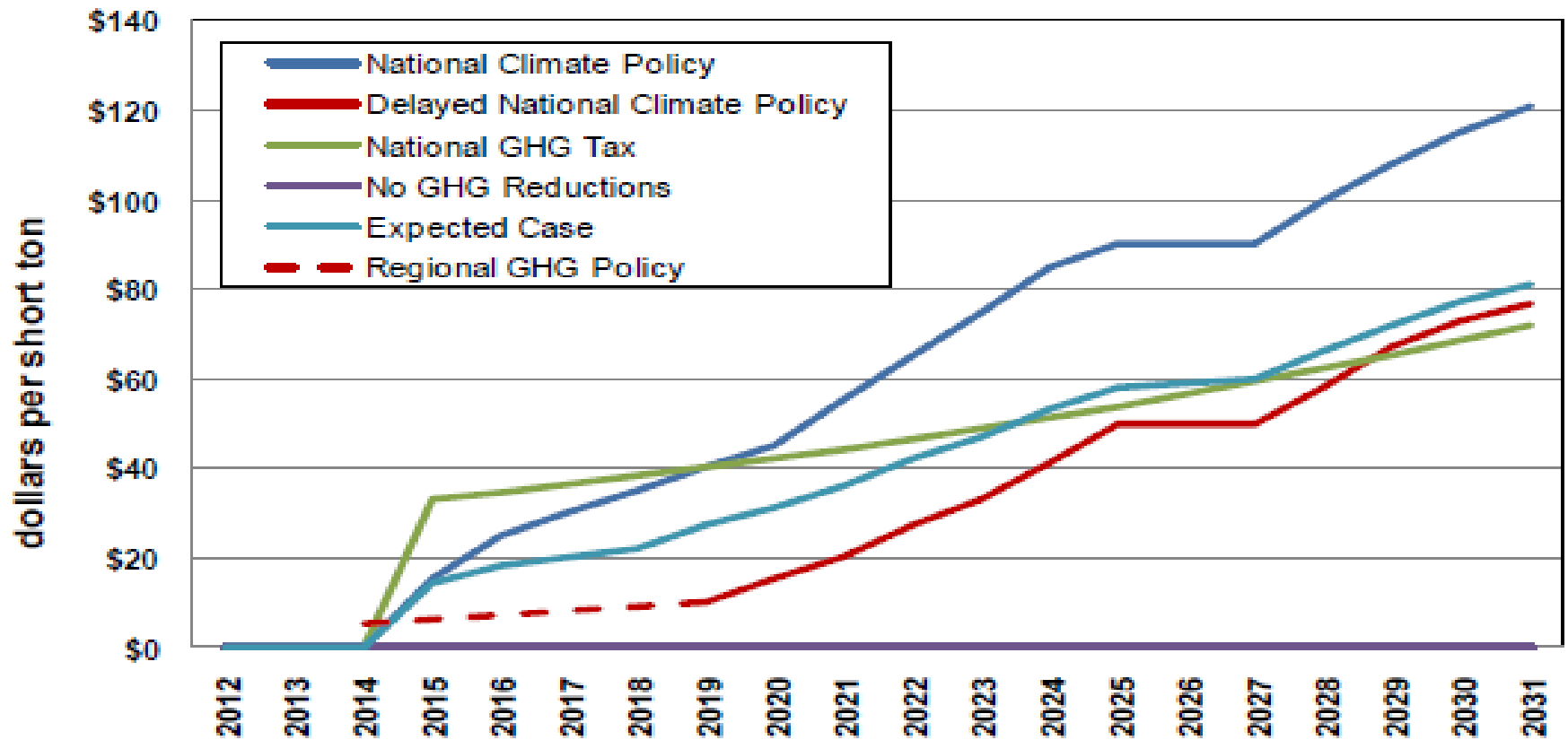
\$ per Ton

Federal Interagency “Social Cost of Carbon for Regulatory Impact Analysis”

Social Cost of CO ₂ , 2010 – 2050 (2010\$)				
Discount Rate Year	5% Average	3% Average	2.5% Average	3% 95 th Percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3

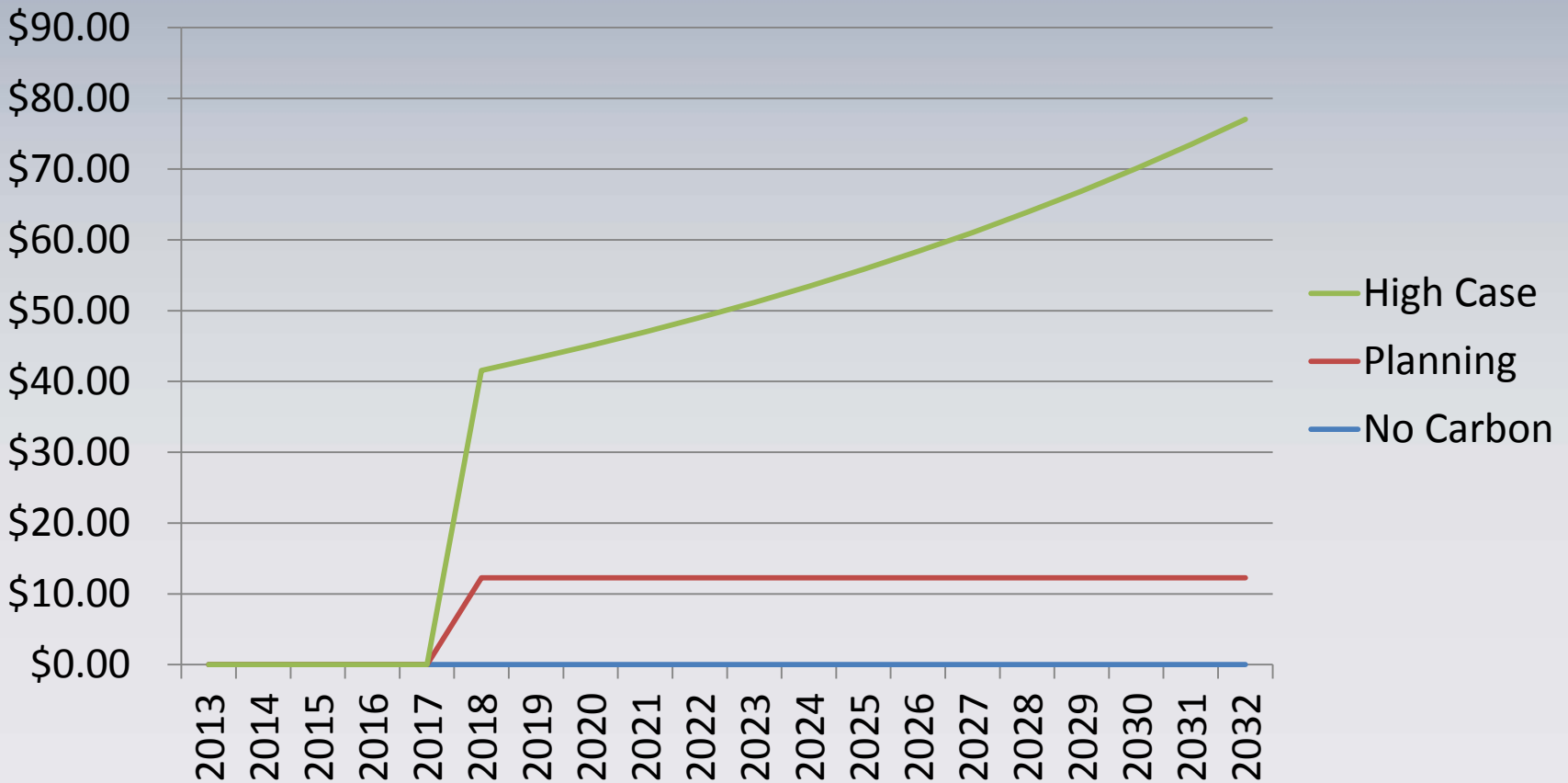
Avista 2011 IRP

Figure 4.2: Price of Greenhouse Gas Credits in each Carbon Policy



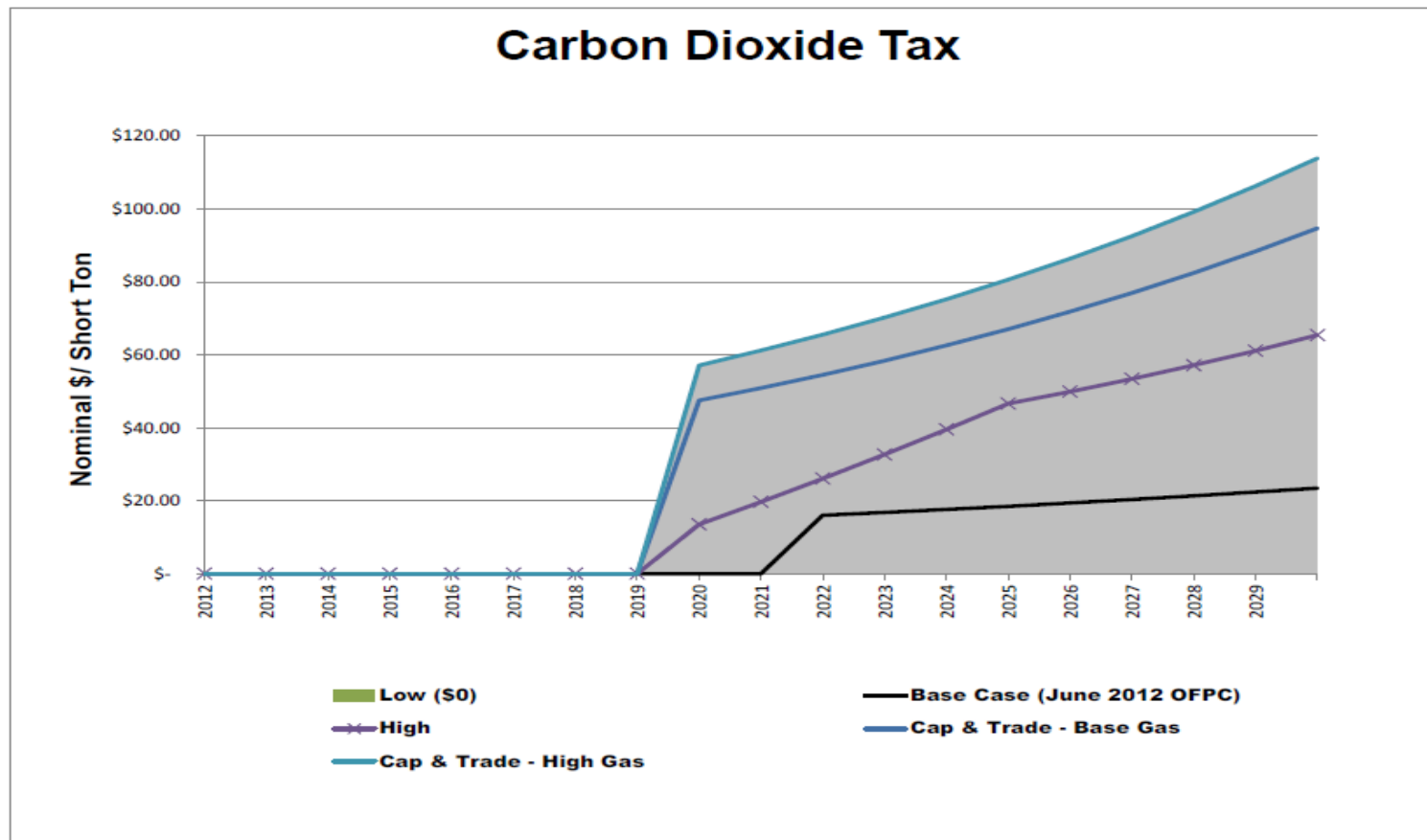
Idaho Power 2013 IRP (Draft)

\$ per Ton Co2 (2012\$)

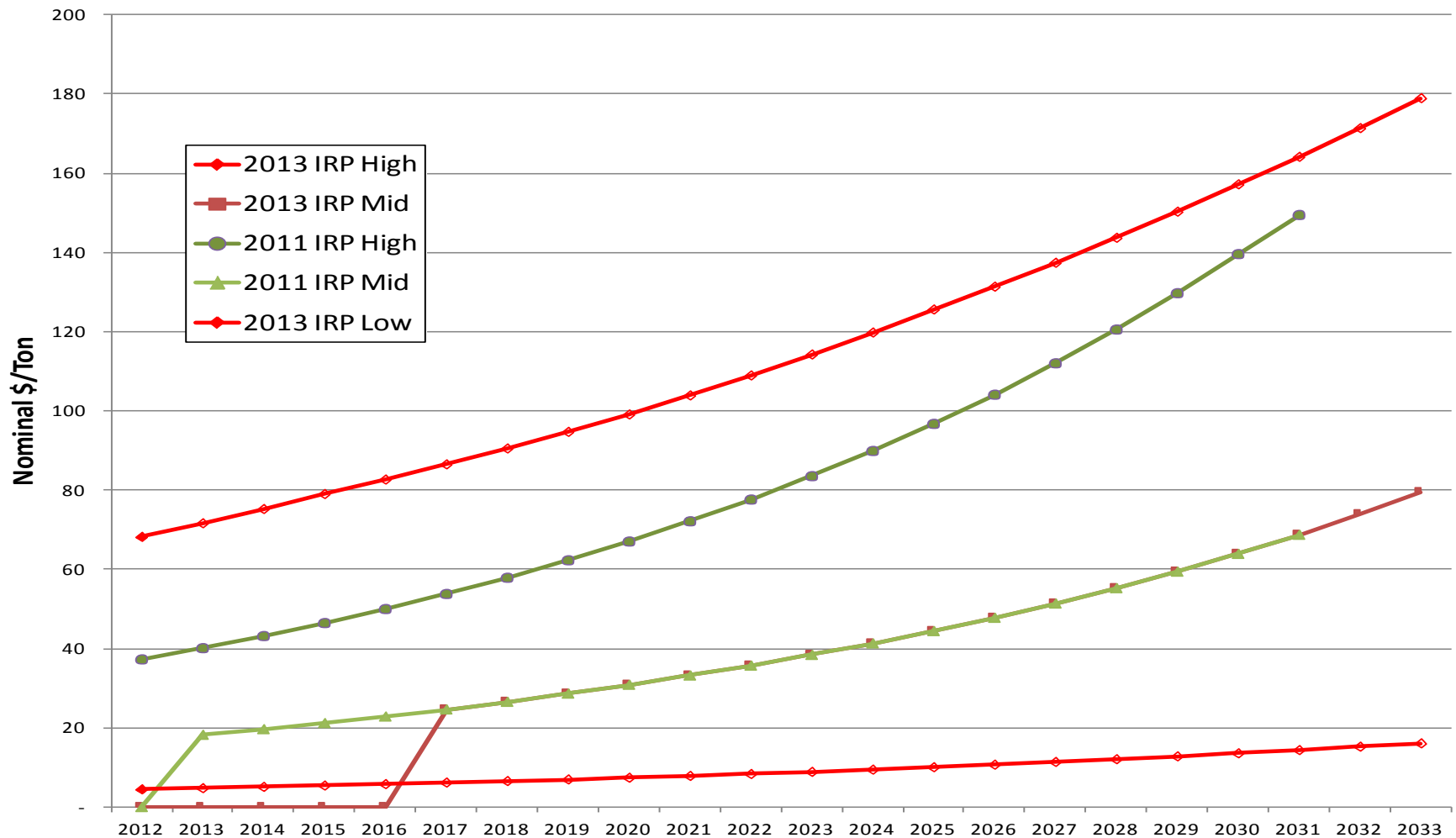


PacifiCorp 2013 IRP

Price Scenarios – CO₂

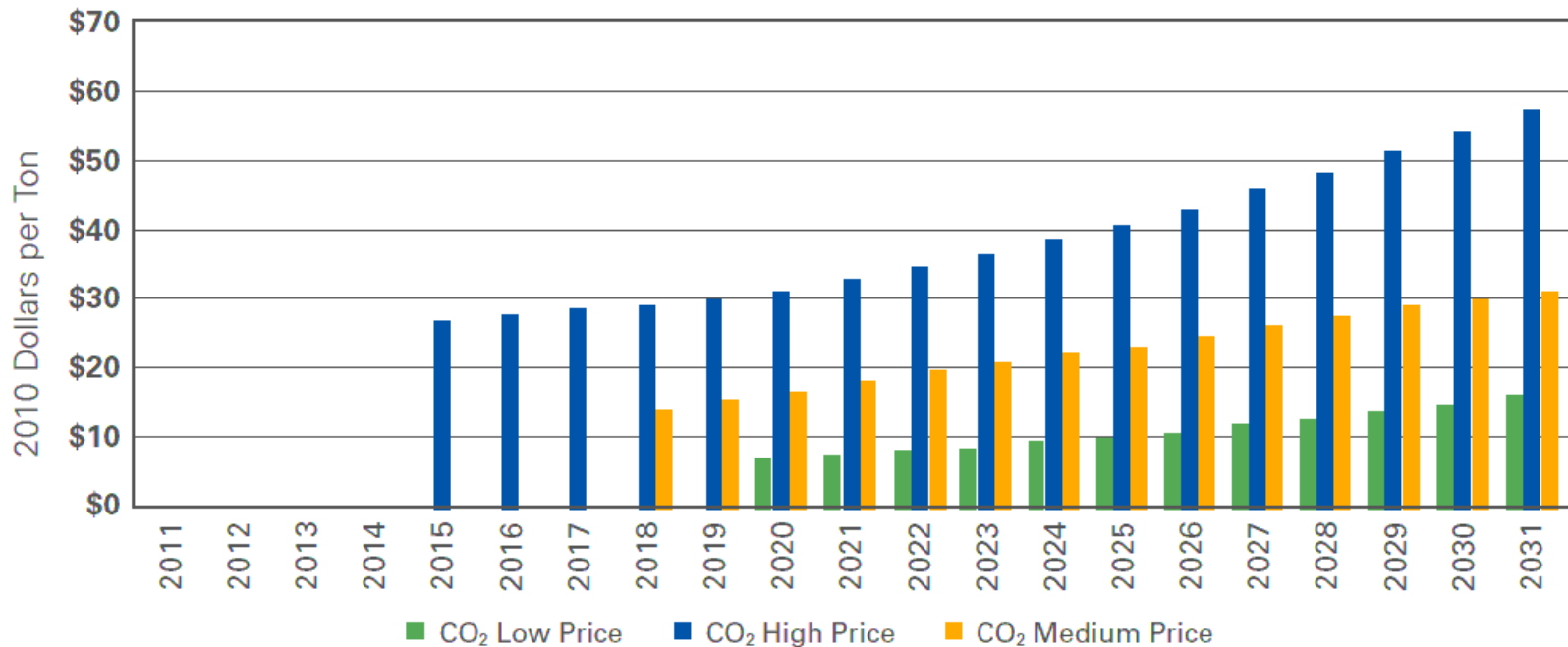


Puget Sound Energy 2013 IRP (Draft)



Seattle City Light 2012 IRP

FIGURE 14: CARBON DIOXIDE EMISSIONS COST SCENARIOS



Snohomish PUD 2010 IRP and 2011 Midterm Assessment

