

Estimating CO2 Reduction of Conservation & Renewable Resources

Jeff King

Northwest Power and Conservation Council
Portland, Oregon

Regional Technical Forum

January 10, 2006

Objective

To estimate the incremental systemwide change in emissions, fuel consumption or other effects of system operation when adding (or removing) specific resources

Examples:

Impact of efficiency measures on systemwide CO₂ production

Systemwide reduction in fuel consumption from CHP development

Effects of modified hydro operation on CO₂ production.

A bit of history

- First attempted this type of analysis about 5 years ago
- Used Aurora and followed the obvious approach
 - running paired capacity addition studies one with and one without a simulated renewable resource (~ 50 MW wind plant)
 - ran for several different initial service years
 - tracked CO2 production directly
- observed irregularities
 - increased CO2 production during certain years
 - large shifts in resource portfolio vs size of test resource
- but accepted general results as they seemed reasonable (~1.6 lb/kWh ???)

Work this last fall for the Energy Trust

- Paired capacity expansion studies

Observed same irregularities as previously, plus inconsistencies vis-a-vis size of test resource addition

Plus, resulting regional resource additions & retirements often deviated significantly from 5th plan portfolio

- Paired studies using a fixed resource mix:

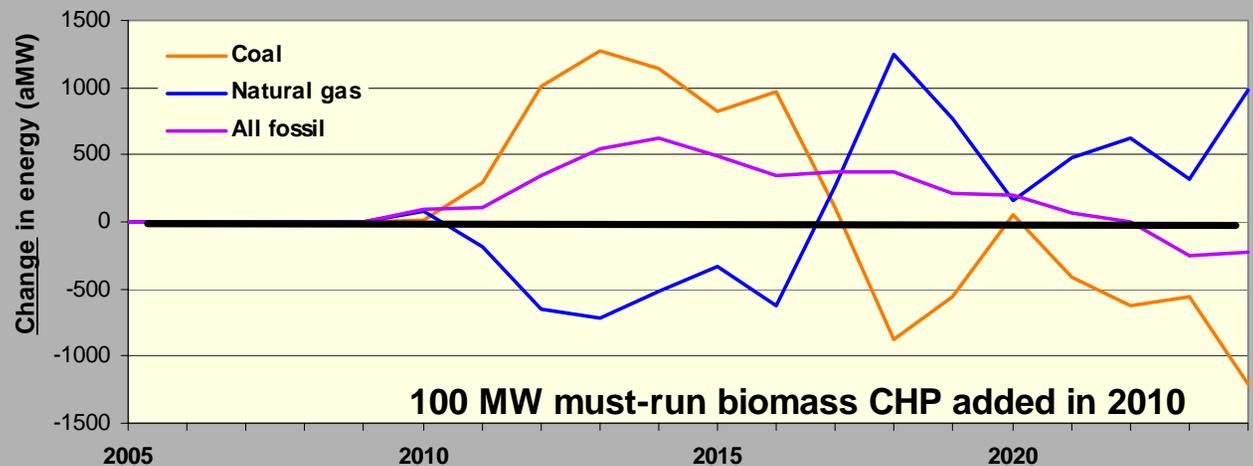
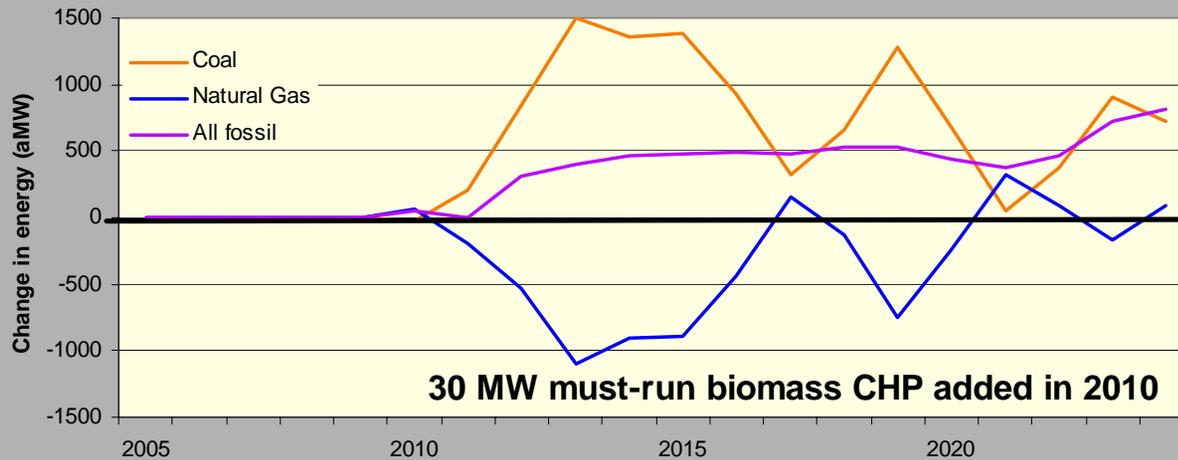
continued to observe inconsistencies vis-a-vis size of added resource.

- Marginal resource analysis using fixed resource mix

Based on the 5th Plan portfolio for the Northwest region

Preliminary work, study will continue later this month

Paired offset analysis using Aurora capacity expansion

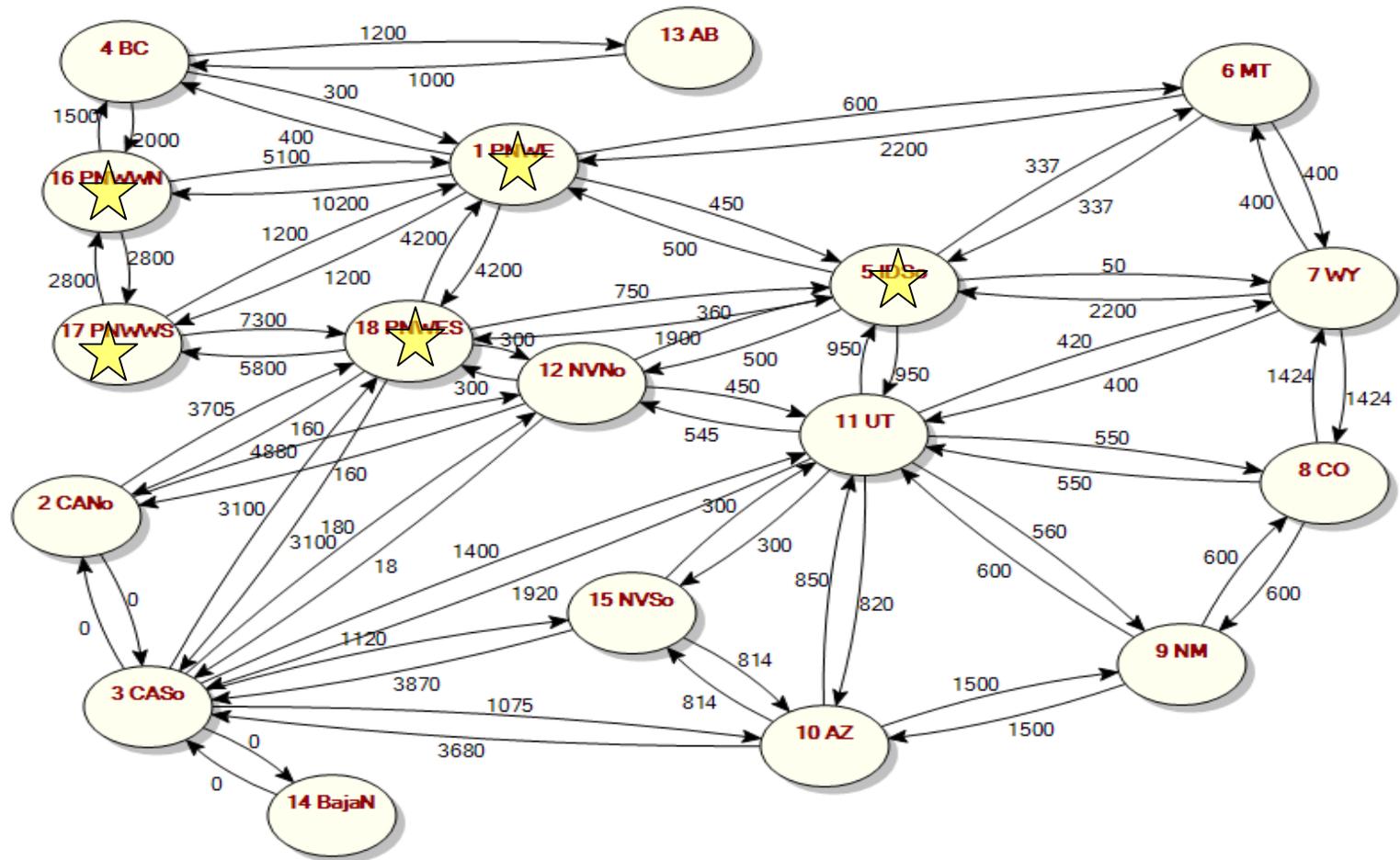


Current analysis: a marginal resource analysis using a fixed resource mix

- Definition of CO2 reduction: CO2 production of hourly marginal resource in Power Act Region
- Fixed resource mix
- Northwest – based on mean value of 5th plan portfolio
- Rest of WECC – Aurora capacity addition study from 5th Plan market price forecast
- Fixed dispatch – resource dispatch does not change in response to addition of new conservation or generation
- Ignores out-of-region marginal resources (imported energy)
- Initially, evaluate 2005 – 25 in 5-year increments.

Geographic scope of marginal resource identification

Not running



Segments

Periods:

| | |
|----------|--|
| On-Peak | M-Sa Hrs 7-22 |
| Off-Peak | M-Sa Hrs 1 - 6, 23, 24; All Hrs Su |
| Seg 1 | M-F Hrs 9 through 18 |
| Seg 2 | M-F Hrs 5 through 8; 19 through 22; Sa & Su 5 through 22 |
| Seg 3 | M-F Hrs 1 through 4; 23 & 24 |
| Seg 4 | Sa & Su Hrs 1 through 4; 23 & 24 |

CO2 emission factors

| Fuel Code | Fuel | CO2 (lb/ MMBtu) |
|-----------|-----------------|-----------------|
| Wat | Hydro | 0 |
| Bio | Biomass | 0 |
| UR | Uranium | 0 |
| NG | Natural Gas | 117 |
| CCSTI | Demand Response | 0 |
| CCSTII | Demand Response | 0 |
| CCSTIII | Demand Response | 0 |
| CCSTIV | Demand Response | 0 |
| CCSTV | Demand Response | 0 |
| FO | FO | 161 |
| Coal | Coal | 212 |

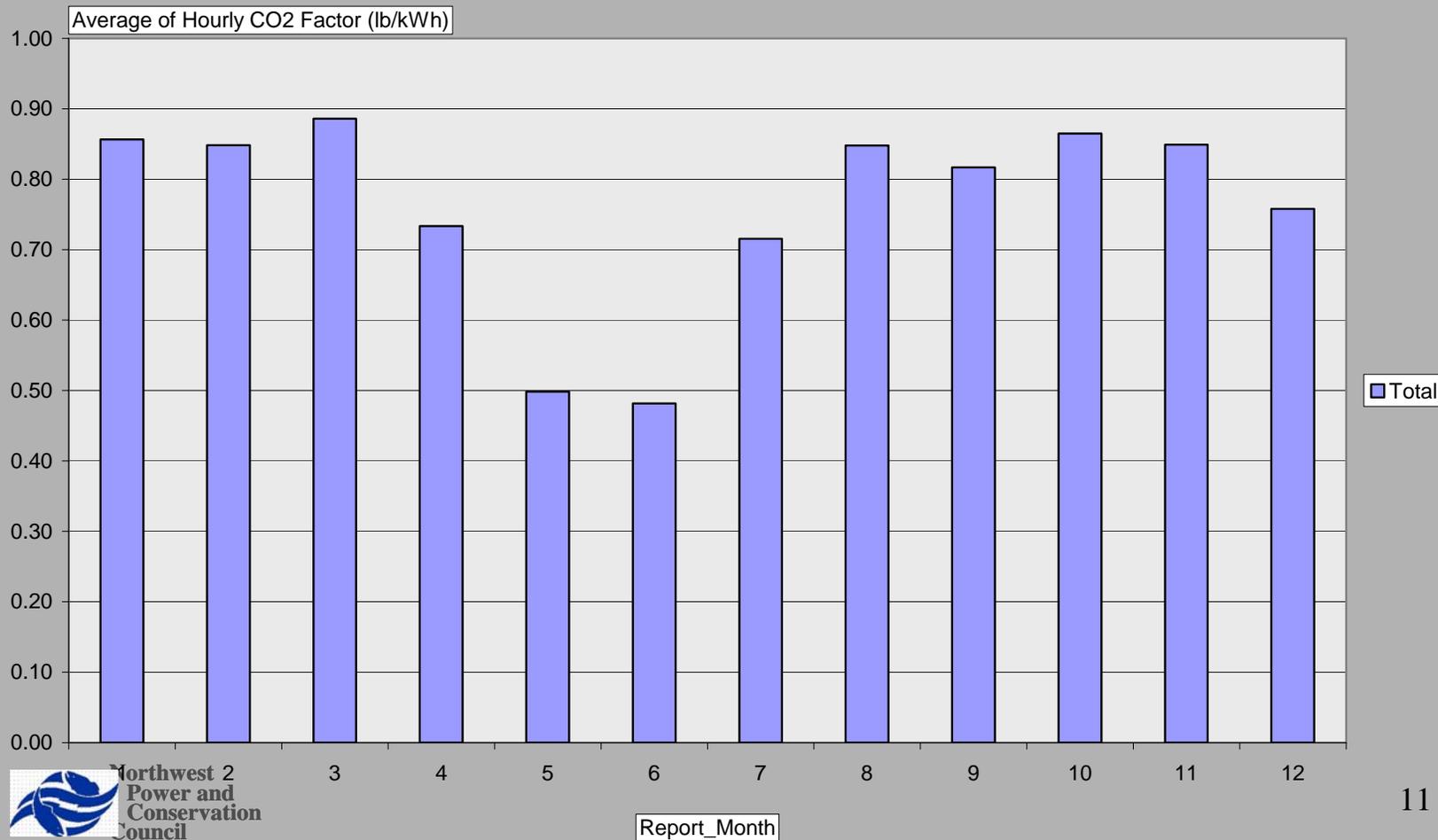
Example marginal resources

| | | | | | | | |
|---------------------|-------------------|-----------------------------|---------|------------------------|------|------|---|
| PNW Ea stside North | 1/4/2010 Hour: 4 | Potlat ch Corp 1-4 | \$13.44 | | 0.00 | 2.30 | 3 |
| Ida ho South | 1/4/2010 Hour: 4 | Brownlee 5 | \$2.69 | | 0.00 | 2.30 | 3 |
| PNW We stside North | 1/4/2010 Hour: 4 | Everett Cogen 1 | \$9.41 | | 0.00 | 2.30 | 3 |
| PNW We stside South | 1/4/2010 Hour: 4 | Bioma ss One | \$13.44 | | 0.00 | 2.30 | 3 |
| PNW Ea stside South | 1/4/2010 Hour: 4 | Boa rdman 1 | \$17.75 | Boa rdman 1 | 2.30 | 2.30 | 3 |
| PNW Ea stside North | 1/4/2010 Hour: 5 | Potlat ch Corp 1-4 | \$13.44 | | 0.00 | 0.59 | 2 |
| Ida ho South | 1/4/2010 Hour: 5 | Simpl ot Poc a tello | \$34.45 | Simpl ot Poc a tello | 0.59 | 0.59 | 2 |
| PNW We stside North | 1/4/2010 Hour: 5 | Centra lia 2 | \$23.53 | | 0.00 | 0.59 | 2 |
| PNW We stside South | 1/4/2010 Hour: 5 | Weyco Energy Center 1 | \$19.49 | | 0.00 | 0.59 | 2 |
| PNW Ea stside South | 1/4/2010 Hour: 5 | Boa rdman 1 | \$17.75 | | 0.00 | 0.59 | 2 |
| PNW Ea stside North | 1/4/2010 Hour: 6 | Bouler Park | \$60.84 | | 0.00 | 0.00 | 2 |
| Ida ho South | 1/4/2010 Hour: 6 | Rupe rt Cogeneration | \$42.36 | | 0.00 | 0.00 | 2 |
| PNW We stside North | 1/4/2010 Hour: 6 | Tena ska 1 | \$49.30 | | 0.00 | 0.00 | 2 |
| PNW We stside South | 1/4/2010 Hour: 6 | De ma nd Response Area 17 5 | \$67.20 | De ma nd Response Area | 0.00 | 0.00 | 2 |
| PNW Ea stside South | 1/4/2010 Hour: 6 | Coyote Springs 2 | \$44.71 | | 0.00 | 0.00 | 2 |
| PNW Ea stside North | 1/4/2010 Hour: 7 | Ra thdrum 2 | \$73.01 | | 0.00 | 1.21 | 2 |
| Ida ho South | 1/4/2010 Hour: 7 | De ma nd Response Area 5 50 | \$67.20 | | 0.00 | 1.21 | 2 |
| PNW We stside North | 1/4/2010 Hour: 7 | Fredonia 4 | \$74.14 | Fredonia 4 | 1.21 | 1.21 | 2 |
| PNW We stside South | 1/4/2010 Hour: 7 | River Road 1 | \$46.84 | | 0.00 | 1.21 | 2 |
| PNW Ea stside South | 1/4/2010 Hour: 7 | Morrow Power | \$73.91 | | 0.00 | 1.21 | 2 |
| PNW Ea stside North | 1/4/2010 Hour: 8 | Finley | \$75.11 | | 0.00 | 1.25 | 2 |
| Ida ho South | 1/4/2010 Hour: 8 | Ben nett Mountain | \$74.68 | | 0.00 | 1.25 | 2 |
| PNW We stside North | 1/4/2010 Hour: 8 | Fredonia 2 | \$76.66 | Fredonia 2 | 1.25 | 1.25 | 2 |
| PNW We stside South | 1/4/2010 Hour: 8 | River Road 1 | \$46.84 | | 0.00 | 1.25 | 2 |
| PNW Ea stside South | 1/4/2010 Hour: 8 | He rmiston Power Project | \$50.31 | | 0.00 | 1.25 | 2 |
| PNW Ea stside North | 1/4/2010 Hour: 9 | De ma nd Response Area 1 50 | \$67.20 | | 0.00 | 1.23 | 1 |
| Ida ho South | 1/4/2010 Hour: 9 | De ma nd Response Area 5 50 | \$67.20 | | 0.00 | 1.23 | 1 |
| PNW We stside North | 1/4/2010 Hour: 9 | Big Ha na ford | \$48.07 | | 0.00 | 1.23 | 1 |
| PNW We stside South | 1/4/2010 Hour: 9 | River Road 1 | \$46.84 | | 0.00 | 1.23 | 1 |
| PNW Ea stside South | 1/4/2010 Hour: 9 | Morrow Power | \$73.91 | Morrow Power | 1.23 | 1.23 | 1 |
| PNW Ea stside North | 1/4/2010 Hour: 10 | Ra thdrum Power Project | \$45.87 | | 0.00 | 0.87 | 1 |
| Ida ho South | 1/4/2010 Hour: 10 | Rupe rt Cogeneration | \$42.36 | | 0.00 | 0.87 | 1 |
| PNW We stside North | 1/4/2010 Hour: 10 | Tena ska 1 | \$49.30 | Tena ska 1 | 0.87 | 0.87 | 1 |
| PNW We stside South | 1/4/2010 Hour: 10 | SP Ne wsprint (Newberg) | \$44.60 | | 0.00 | 0.87 | 1 |
| PNW Ea stside South | 1/4/2010 Hour: 10 | He rmiston Generating 2 | \$46.87 | | 0.00 | 0.87 | 1 |

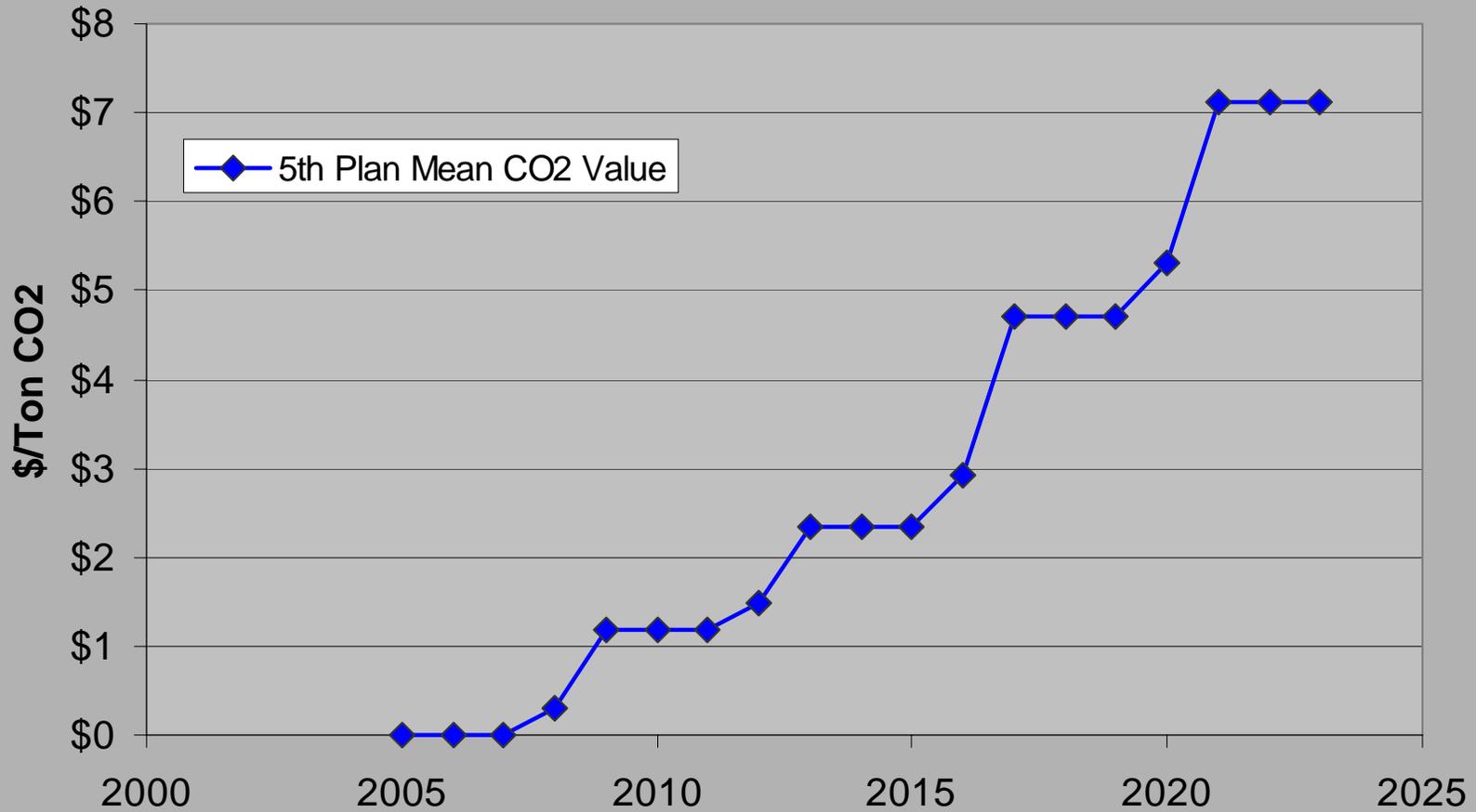
Marginal CO2 production: All hours by month for 2010

Segment (All) Report_Year 2010

Total



Mean CO2 value from 5th Plan



Marginal CO2 Offset Value (\$/MWh) – All hours, 2010

| | |
|-------------|------|
| Report_Year | 2010 |
|-------------|------|

CO2 Value **1.19**

| Average of Hourly CO2 Factor (lb/kWh) | |
|---------------------------------------|---------|
| Report_Month | Total |
| | 1 0.86 |
| | 2 0.85 |
| | 3 0.89 |
| | 4 0.73 |
| | 5 0.50 |
| | 6 0.48 |
| | 7 0.72 |
| | 8 0.85 |
| | 9 0.82 |
| | 10 0.86 |
| | 11 0.85 |
| | 12 0.76 |

\$/MWh
\$0.51
\$0.50
\$0.53
\$0.44
\$0.30
\$0.29
\$0.43
\$0.50
\$0.49
\$0.51
\$0.51
\$0.45

Issues

- Estimates based on marginal resource CO2 production and a fixed resource mix probably OK for small, constant output resources not significantly affecting resource dispatch or future resource mix.
- “Paired” analysis desirable for resources expected to significantly affect resource dispatch
- Comparative capacity expansion analysis desirable for resources having the potential to affect future resource mix.
- New version of Aurora and improved resource commitment assumptions may make revisiting these approaches worthwhile.

Other issues

- CO2 emission factors
 - biomass is assumed to be zero
- Geographic area
- Must-run biomass cogen plants
- Time period
 - 2005 - 2025
- Natural gas price assumptions
 - Medium 5th Plan forecast
- Granularity
 - 4 segments by month
- Value of CO2 reduction
 - Mean value of 5th Plan portfolio risk analysis