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INTERMITTENCY ANALYSIS PROJECT: APPENDIX B IMPACT OF INTERMITTENT GENERATION ON OPERATION OF CALIFORNIA POWER GRID

PIER FINAL PROJECT REPORT

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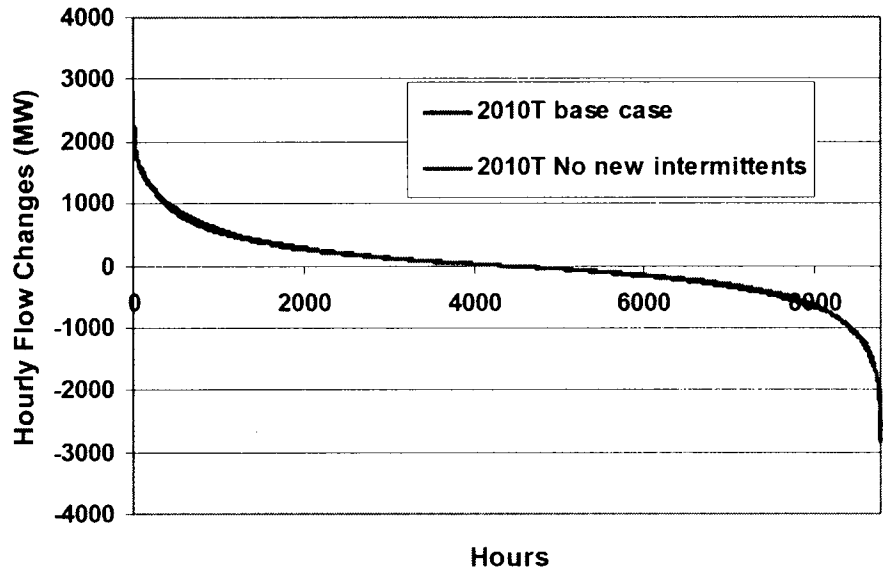

Figure 123. Annual Duration Curve for Hourly Flow Changes on Path 66: COI (2010T).

4.7. Observations

The introduction of any new generation into California will impact the cost of energy as reflected in the spot prices not only within California but throughout WECC. This is particularly true of renewable generators that tend to enter the market as "price takers" (even though the price paid for the energy is not zero). The impacts were generally rather moderate, although they could be more severe in some hours, with the significant drop in spot prices indicating that the system is running low on generation that can be maneuvered downward. The 2010T scenario had about 250 hours in the year with this more severe impact. The 33% penetration of renewables in the 2010X scenario increased this to about 500 hours.

Table 27 shows the average reductions in operating costs for all of WECC per MWh of the renewable generation. The decreased value of the wind and solar generation is due to their intermittent nature.

Table 27. Average Variable Operating Cost Reductions per MWh of Renewable Energy (2010T).

	WECC ($/MWh)
Biomass & Geothermal	39.48
Wind & Solar	29.90

Table 28 shows the average load payment reductions in both California and all of WECC per MWh of the renewable generation.

Table 28. Average Load Payment Reductions per MWh of Renewable Energy (2010T).

	California ($/MWh)	WECC ($/MWh)
Biomass & Geothermal	8.97	19.66
Wind & Solar	11.41	28.86

The non-renewable generators have their revenue reduced from two sides. The system spot prices in general have decreased so that they receive less revenue for each MWh of energy produced and in addition the amount of energy that they are producing has been reduced due to displacement by the renewable generation. Table 29 shows the impact in California and all of WECC for each type of renewable generation.

Table 29. Average Non-Renewable Generator Revenue Reduction per MWh of Renewable Energy (2010T).

	California ($/MWh)	WECC ($/MWh)
Biomass & Geothermal	23.98	69.17
Wind & Solar	17.78	47.42

It is of critical importance that the intermittent renewable generation be centrally forecasted and *published* in the day ahead market along with the load forecast in order that the market can properly respond to the intermittent generation. The impact of ignoring the intermittents in the commitment process was an order of magnitude greater than the impact of the displacement when they were properly accounted for, as summarized in Table 30.

Table 30. Annual Load Payment Reductions from Intermittent Generation (2010T).

	California ($ Millions)	WECC ($ Millions)
Wind & Solar with an estimated forecast	240	607
Ignoring Wind & Solar forecast in the commitment process	2231	6330

The addition of renewable generation reduced the total emissions throughout WECC. Table 31 shows the average emission reductions in WECC per MWh of renewable generation.

Table 31. Average Annual Emission Reductions in WECC per MWh of Renewable Generation (2010T).

	NOx (lbs/MWh)	SOx (lbs/MWh)	CO2 (lbs/MWh)
Biomass & Geothermal	130	10	830
Wind & Solar	117	46	810

In general it was shown that the energy displacement both inside California and throughout WECC was predominantly on the combined cycle generation. Roughly 40% of the displaced

energy fell on units within California and 60% displaced imports coming from the rest of WECC. The hydro generation within California was adjusted based on the day ahead forecast for the intermittent generation. In the 2010T scenario, over 7500 MW of Wind generation only introduced shifts of roughly +/- 1500 MW in the hydro operation. Some hydro schedules outside of California were affected but the bulk of the modifications occurred in state. Historical operation indicated that these shifts should be well within the capability of the system most of the time. Pumped storage hydro operation increased as additional renewable generation was added but there didn't appear to be a need for additional PSH capacity. The exception to this might occur if the conventional hydro is severely constrained. In that case, the PSH activity increased significantly.

Overall ,with proper application of existing technology, using the existing and planned infrastructure and with appropriate policy changes to encourage flexibility in operation, there was not any significant operational problems identified at the hourly level to the introduction of renewable energy penetrations of up to 33%.