

# MIO Pricing Formulations and March Sandbox Simulation Results

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- » **Market clearing price may be established by a “strategic” offer designed to achieved a specific dispatch.**
  - Consider a unit that submits a high offer price in the next hour in order to be dispatched off.
  - At the start of the next hour, the DSO software determines that the unit is no longer economical and dispatches the unit down at its offered ramp rate.
  - If the unit takes 1 hour to ramp down to its minimum, it will be setting the clearing price over this hour.
- » **Results in gaming opportunities.**
  - Incentive for high priced resources to have slow ramp down rates

- » **Highest Slice Price can be less than the Incremental Price.**
  - Observed in simulation tests.
  - Maximum difference of \$35 observed in one interval.
  - Results from the price impact of joint energy and reserve optimization which is not incorporated into the HSP methodology.

## » Example

- Consider two 50MW units who offered energy/reserve prices of \$90/\$5 and \$150/\$30 respectively.
- Reserve requirement 20MW; energy requirement increasing.
- Energy [ 30MW: both energy and reserve from the first unit.
- The next MW of energy may come from the second unit (\$150) or from the first unit by redispatching reserve ( $\$90 - \$5 + \$30$ ).
- The incremental energy and reserve clearing prices are \$115/\$30 and the HSP are \$90/\$30.
- Under HSP the first unit is NOT held harmless as it would be better off providing reserve rather than additional energy.

- » **MIO Incremental Price can be lower than the real incremental price for certain intervals.**
  - **The MIO algorithm will ramp up higher priced units (normally slow start units) early to economically meet future demand.**
  - **Other units (normally quick start units) will be ramped down to maintain the generation-load balance.**
  - **The Highest Slice Price (HSP) will be the price of the ramped up unit with the highest offer price.**
  - **The MIO Incremental Price will be the price of the ramped down unit with the lowest offer price.**

» **Two alternative pricing formulations were identified that would rectify the problems associated with the current MIO pricing method.**

## **1) Modified HSP#1 (MHSP#1)**

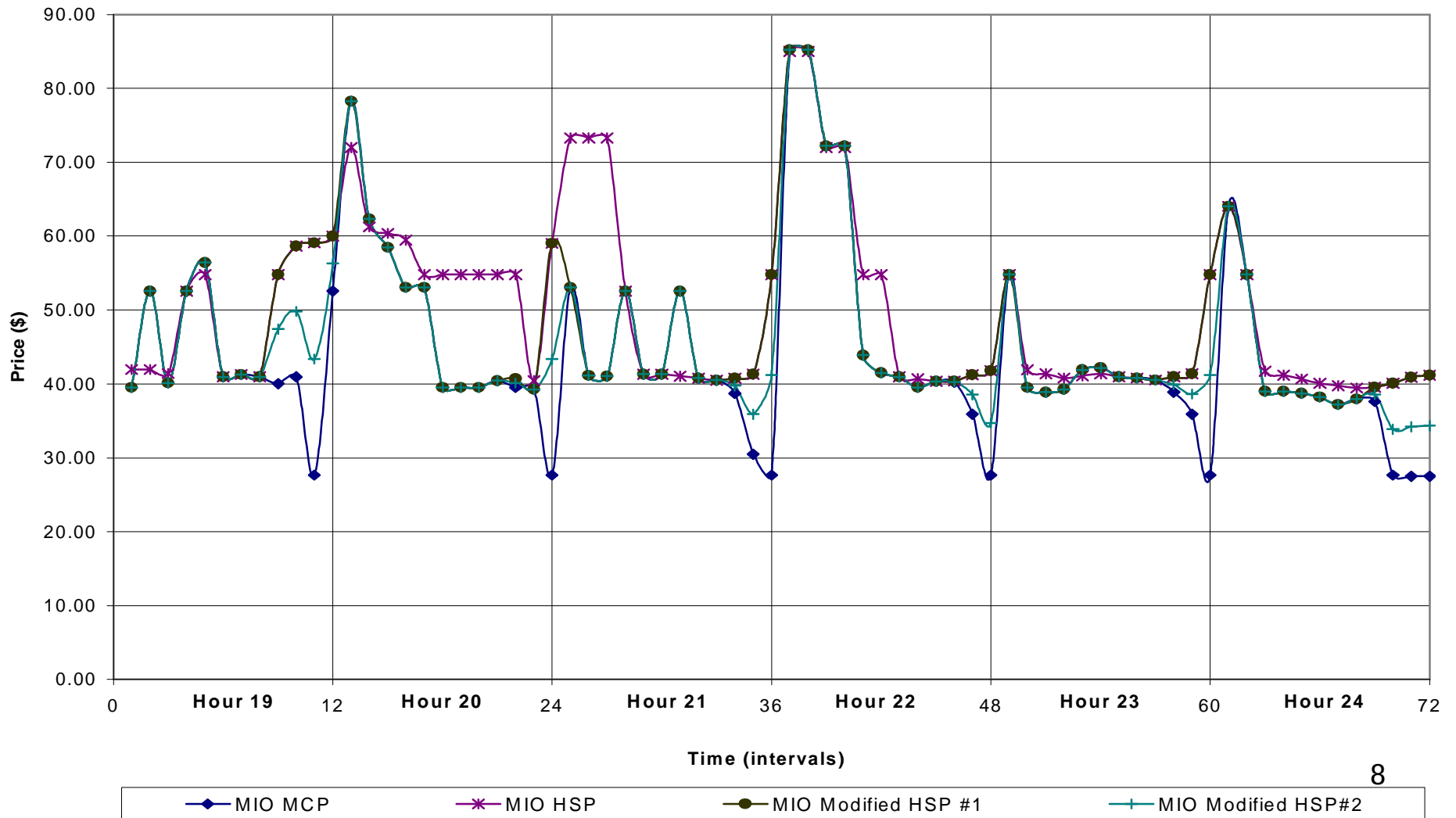
- **Uses the MIO incremental price as a base (avoids the second consequence of the HSP approach).**
- **If, in the interval, a unit that is ramping up has a price higher than the MIO incremental price, let it set the price (avoids the consequence of the MIO incremental approach).**

## **2) Modified HSP#2 (MHSP#2)**

- **Same as the MHSP#1 except that the clearing price is set as the average of the MIO incremental price and the ramping up unit price, where they are different.**

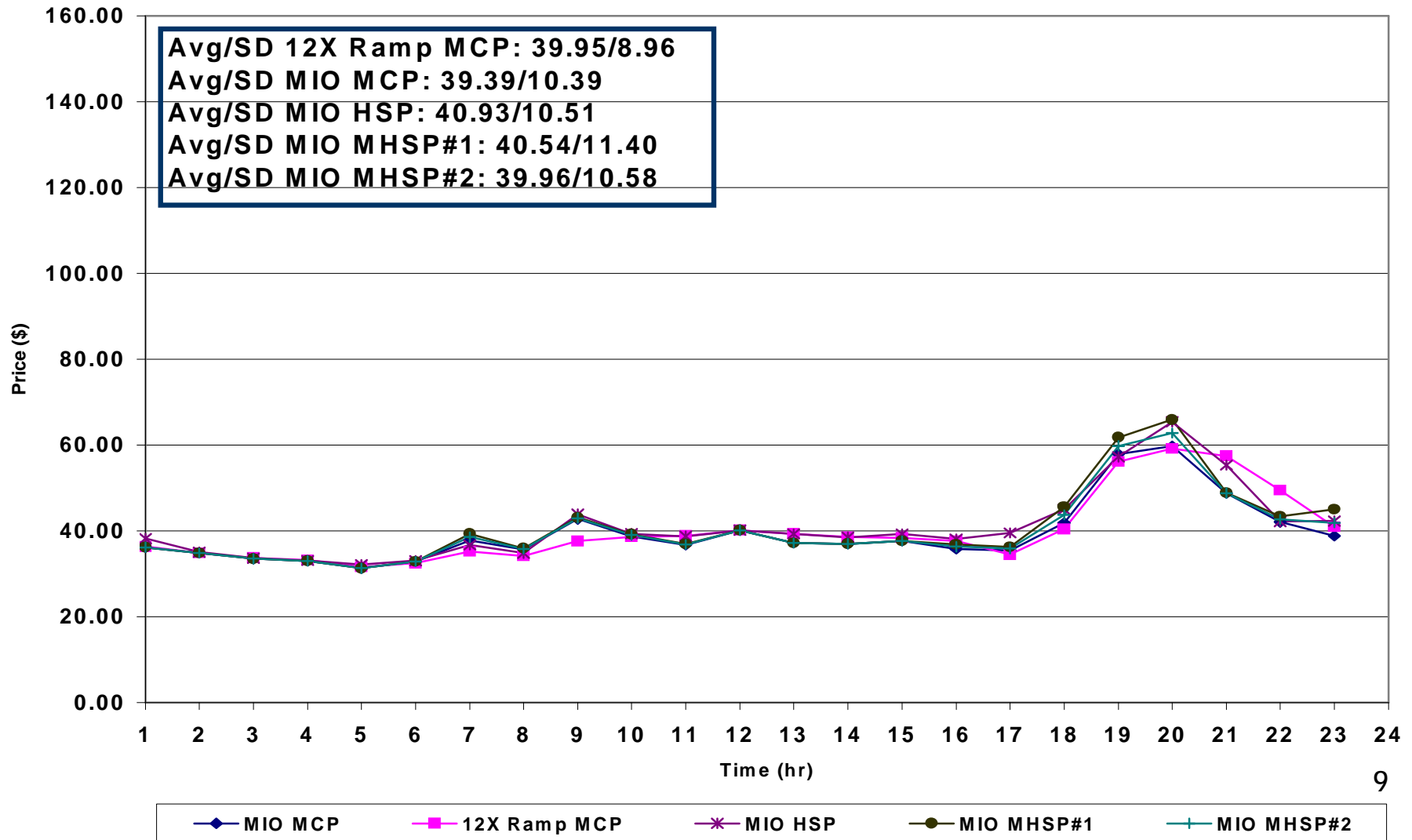
- » **Prices based on the two alternative pricing formulations were calculated for the two test periods.**
- » **The following slides show the hourly prices for both the current and alternative pricing formulations.**
- » **The summary tables at the end provide daily and study period statistics.**

**Graph 1. Interval Prices for Hour 19 - 24 Feb.5,2004**



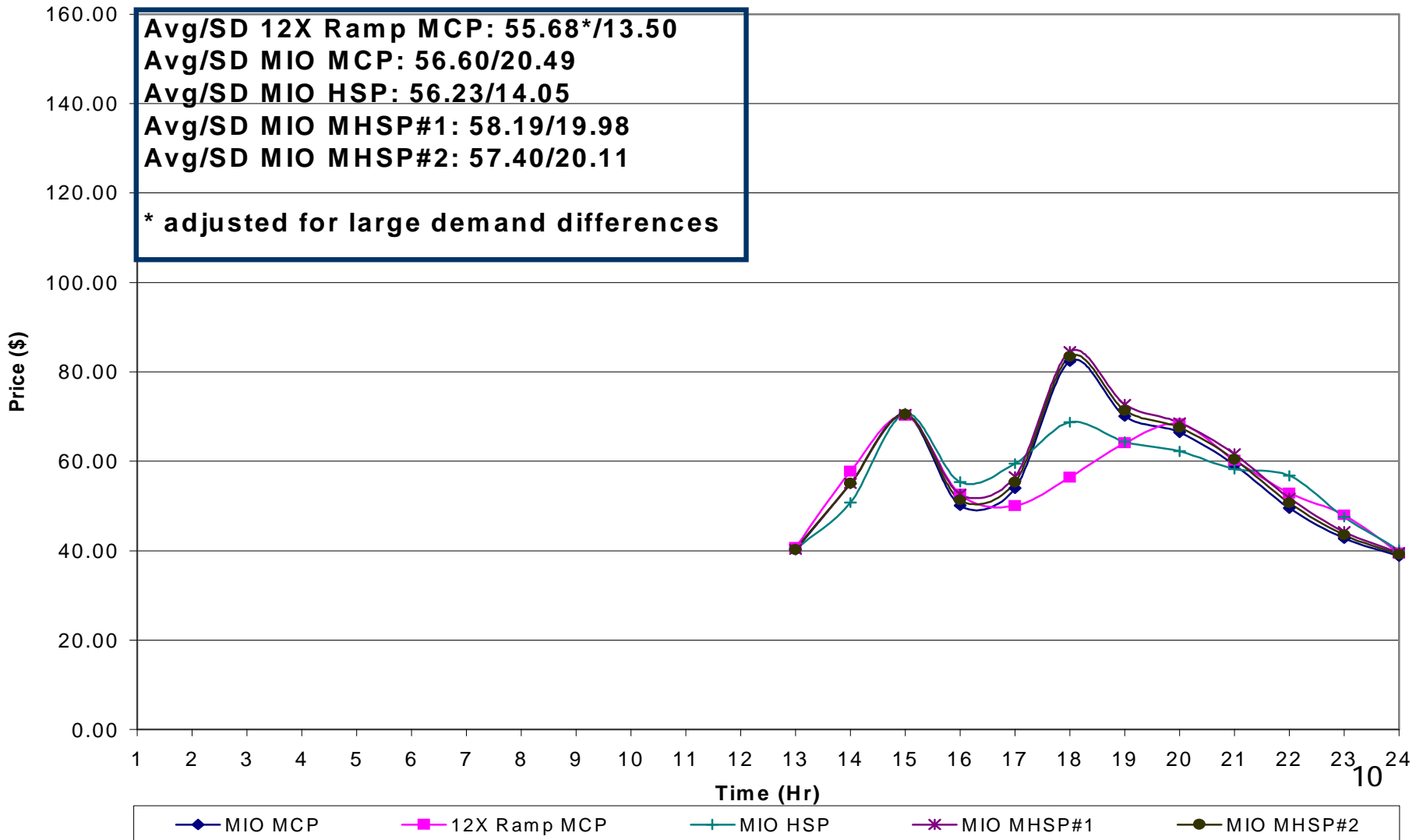
# Comparison of Pricing Methods

**Graph 2. Various Prices for Dec.11, 2004**

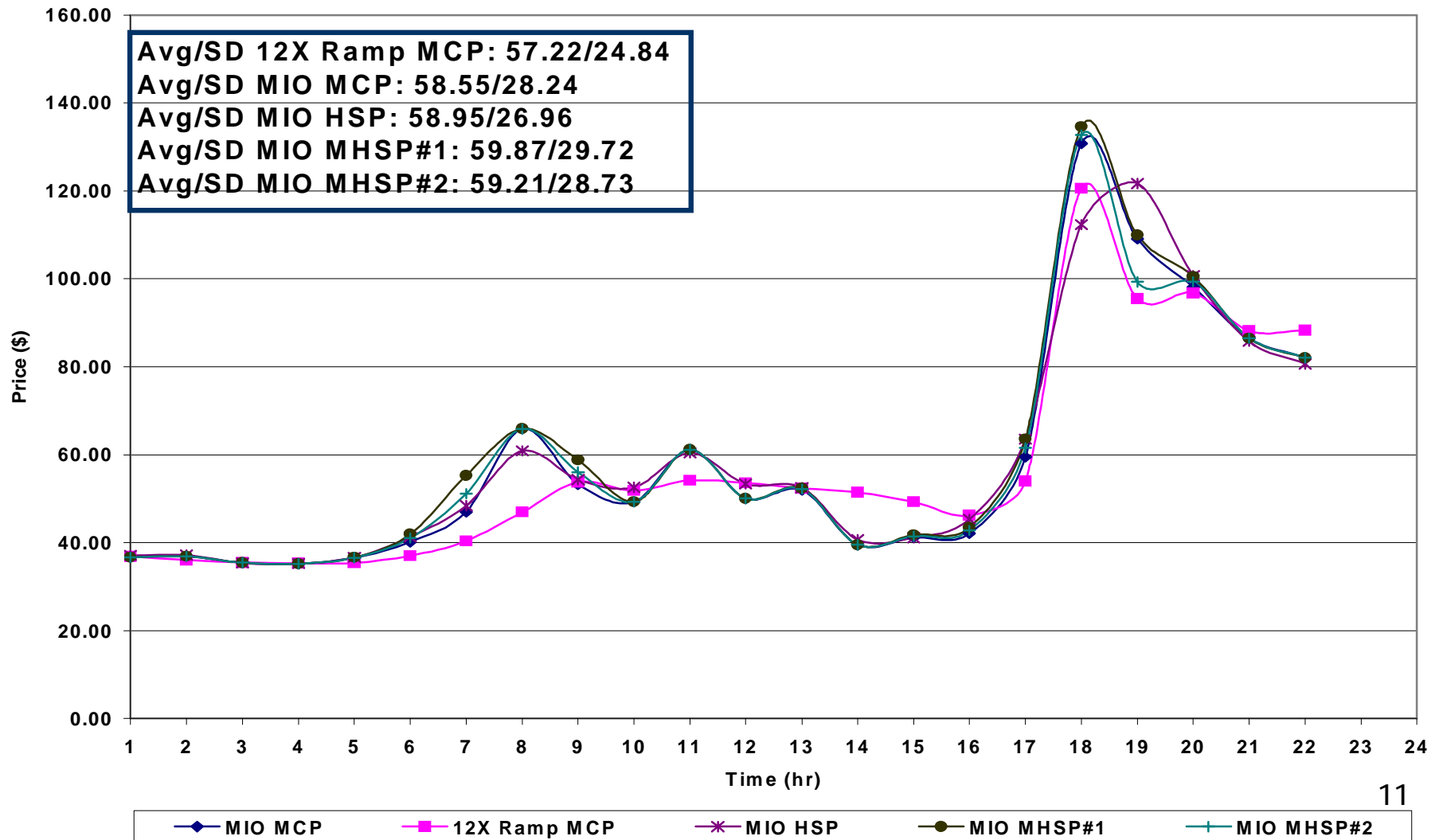


# Comparison of Pricing Methods

**Graph 3. Various Prices for Dec.12, 2004**

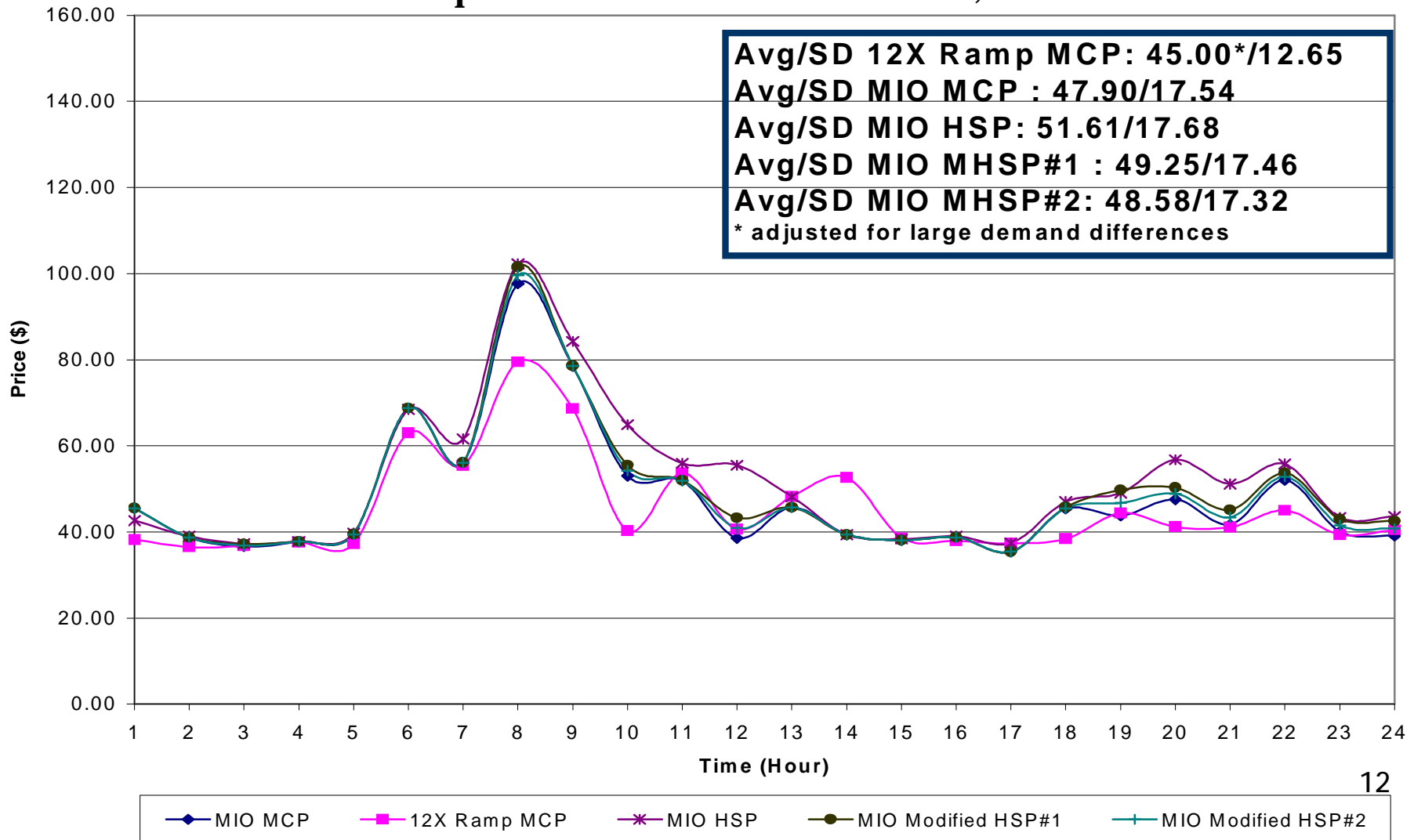


**Graph 4. Various Prices for Dec.13, 2004**

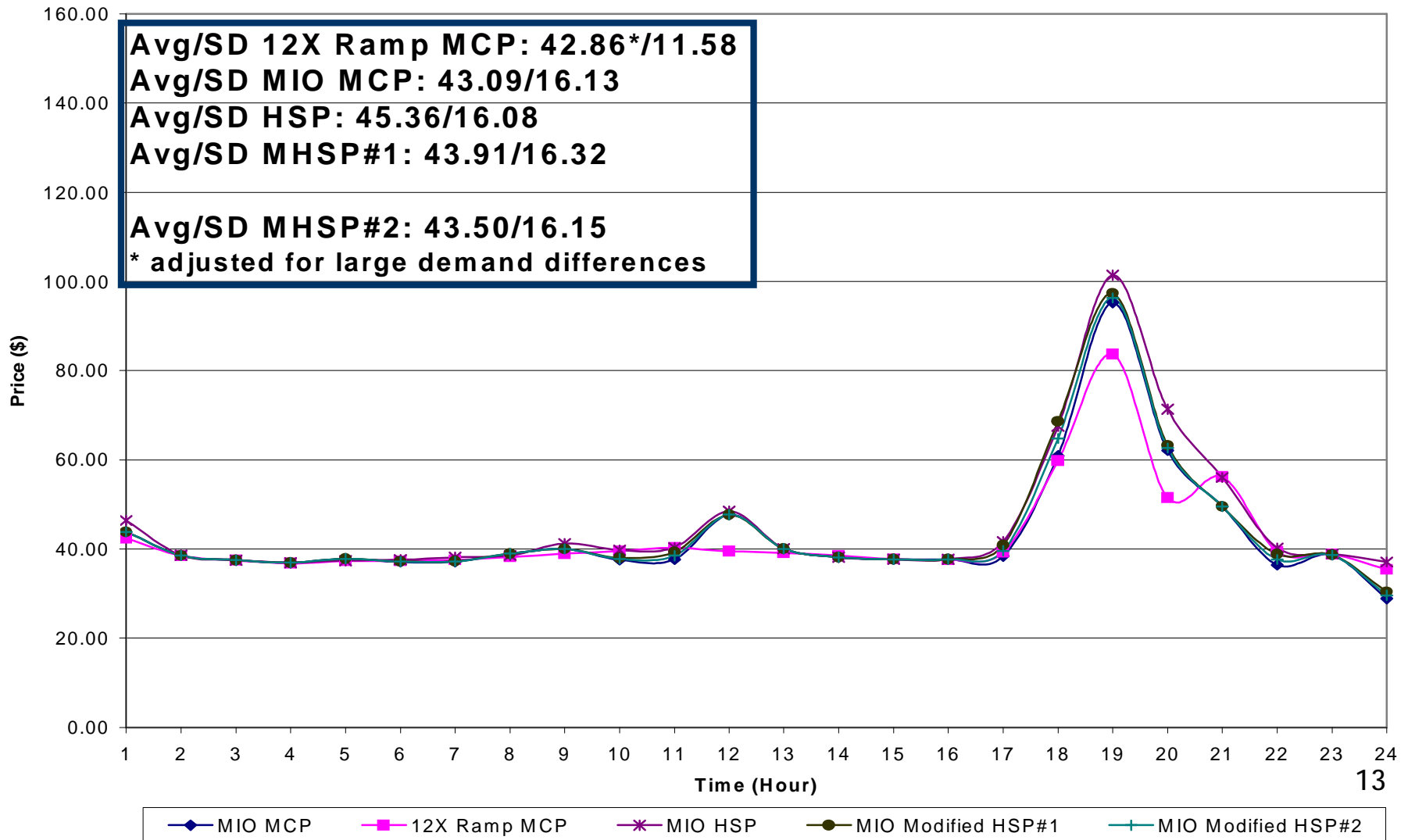


# Comparison of Pricing Methods

**Graph 5. Various Prices for Feb05, 2005**

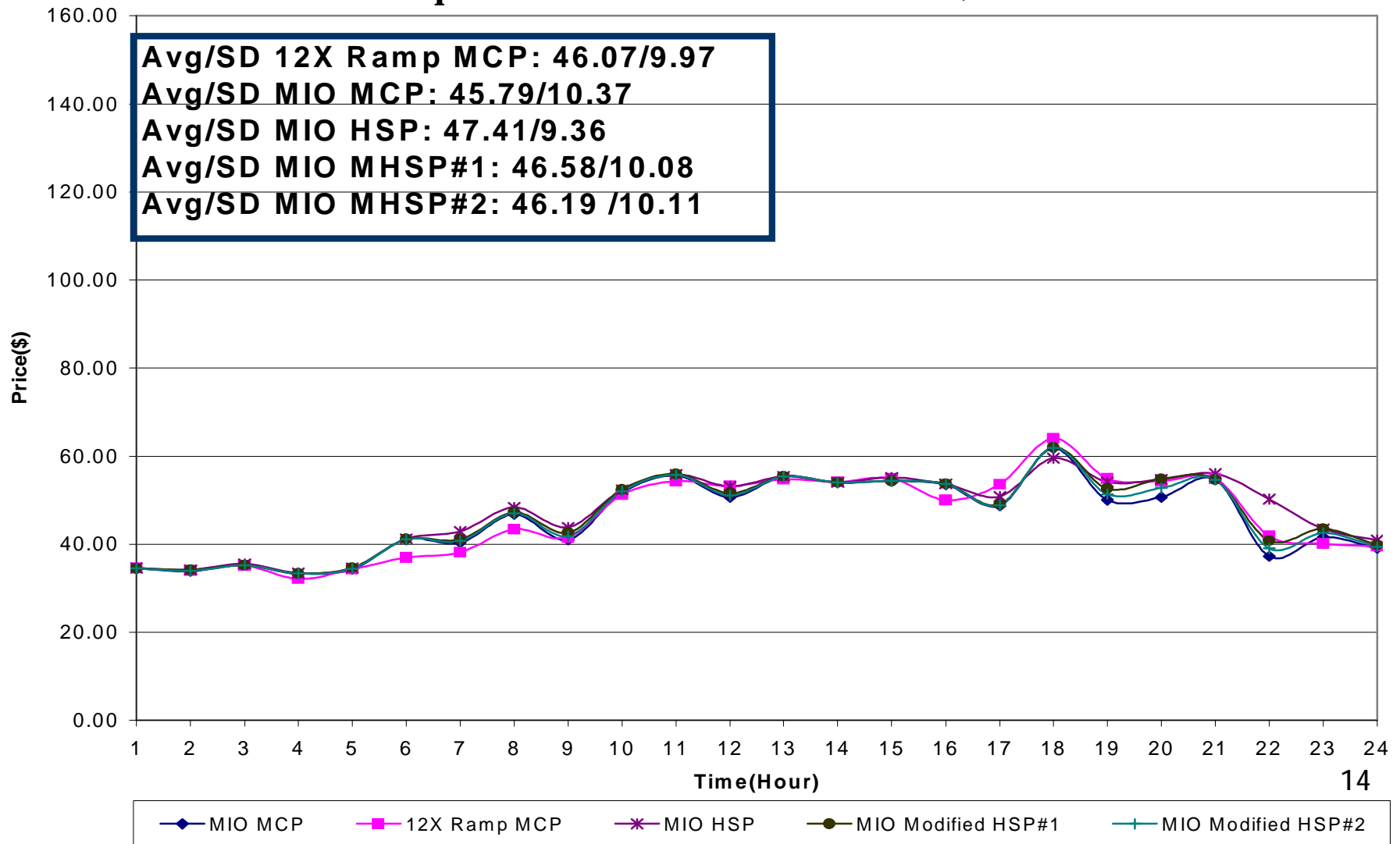


**Graph 6. Various Prices for Feb.06, 2005**



# Comparison of Pricing Methods

**Graph 7. Various Prices for Feb.07, 2005**



# Summary of Average Daily Prices

**Table 1. Average Daily Prices**

<b>Date</b>	<b>12X Ramp MCP</b>	<b>MIO MCP (INC.)</b>	<b>MIO HSP</b>	<b>MIO MHSP#1</b>	<b>MIO MHSP#2</b>
<b>Dec.11/04</b>	<b>39.95</b>	<b>39.9</b>	<b>40.93</b>	<b>40.54</b>	<b>39.96</b>
<b>Dec.12/04</b>	<b>55.68*</b>	<b>56.60</b>	<b>56.23</b>	<b>58.19</b>	<b>57.40</b>
<b>Dec.13/04</b>	<b>57.22</b>	<b>58.55</b>	<b>58.95</b>	<b>59.87</b>	<b>59.21</b>
<b>Feb.5/05</b>	<b>45.00*</b>	<b>47.90</b>	<b>51.61</b>	<b>49.25</b>	<b>48.58</b>
<b>Feb.6/05</b>	<b>42.86*</b>	<b>43.09</b>	<b>45.36</b>	<b>43.91</b>	<b>43.50</b>
<b>Feb.7/05</b>	<b>46.07</b>	<b>45.79</b>	<b>47.41</b>	<b>46.58</b>	<b>46.19</b>

**\* Results were adjusted for large demand differences**

# Summary of Average Daily Prices

**Table 2. Average Percentage Change in Daily Prices Compared to the 12X Ramp MCP**

<b>Date</b>	<b>MIO MCP (INC.)</b>	<b>MIO HSP</b>	<b>MIO MHSP#1</b>	<b>MIO MHSP#2</b>
<b>Dec.11/04</b>	<b>-1.41</b>	<b>2.44</b>	<b>1.46</b>	<b>0.02</b>
<b>Dec.12/04</b>	<b>2.77</b>	<b>0.99</b>	<b>4.51</b>	<b>3.09</b>
<b>Dec.13/04</b>	<b>2.32</b>	<b>3.01</b>	<b>4.63</b>	<b>3.48</b>
<b>Feb.5/05</b>	<b>6.44</b>	<b>14.68</b>	<b>9.44</b>	<b>7.96</b>
<b>Feb.6/05</b>	<b>0.54</b>	<b>5.83</b>	<b>2.45</b>	<b>1.49</b>
<b>Feb.7/05</b>	<b>-0.61</b>	<b>2.91</b>	<b>1.12</b>	<b>0.25</b>
<b>Average All Days</b>	<b>1.49</b>	<b>4.98</b>	<b>3.94</b>	<b>2.72</b>
<b>Average Excluding Feb.5/05 #</b>	<b>0.5</b>	<b>3.04</b>	<b>2.83</b>	<b>1.67</b>
<b># Problems associated with Feb.5/05 were discussed at MPWG meeting #15</b>				<b>16</b>

- » **Different demands used in the constrained and the unconstrained sequences during certain days of the simulation due to tool problems.**
- » **The average daily 12X Ramp price was adjusted accordingly:**
  - **March 12: Reduction of \$3.00/MW due to major demand differences in hour 14 and minor differences in hour 10 and 11.**
  - **March 13: Reduction of \$2.34/MW due to demand differences in hours 14 and 18 to 24.**
  - **March 16: Reduction of \$5.00 due to tool problem (hours 1 to 3) and demand differences in (9, 10, 11, 20, 21, 22 and 24)**

» **The 12X Ramp prices were higher than MIO prices in some days due to the following:**

**Two large units were in service and marginal.**

- **MIO sequence kept them at or above their  $P_{min}$  level.**
- **The unconstrained sequence allowed them to go down to zero.**
- **With the units at or above  $P_{min}$ , MIO sequence can ramp the unit at its normal ramp rate up or down.**
- **The ramp up rate for these units when they are below  $P_{min}$  is very low, so the unconstrained sequence could not schedule the unit as high as the MIO sequence could. The ramp down rate for the units when below  $P_{min}$  is similar to the ramp rate when above  $P_{min}$ .**

## 12X Ramp Prices Higher Than MIO Prices cont.

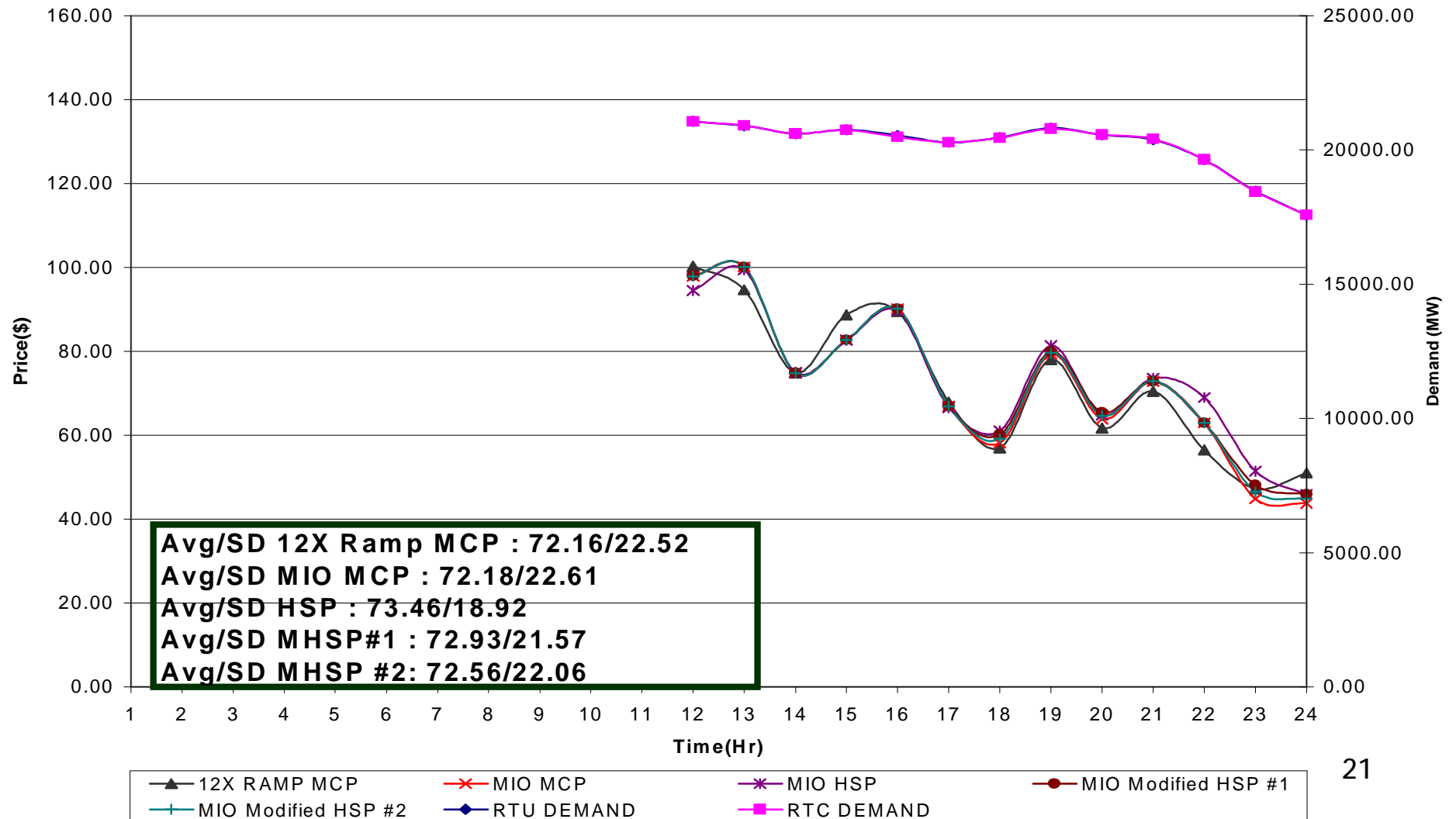
- » **When the units were not economic, the unconstrained sequence took them down to 0 MW at a fast rate while MIO sequence kept them at Pmin.**
  - Their Pmin output reduced the requirements from the other units and resulted in lower MIO prices.
- » **When the units were economic, the unconstrained sequence ramped them up at the lower ramp rate while the MIO sequence was able to ramp them up faster.**
  - Resulted in even lower MIO prices.

# March Sandbox Simulation Results

- » **The following graphs depict the results from the March 11, 2005 to March 16, 2005 Sandbox Simulation.**
- » **Note that the graphs and statistics displayed are not adjusted in any way to accommodate for the tool and demand differences identified in the previous slide.**

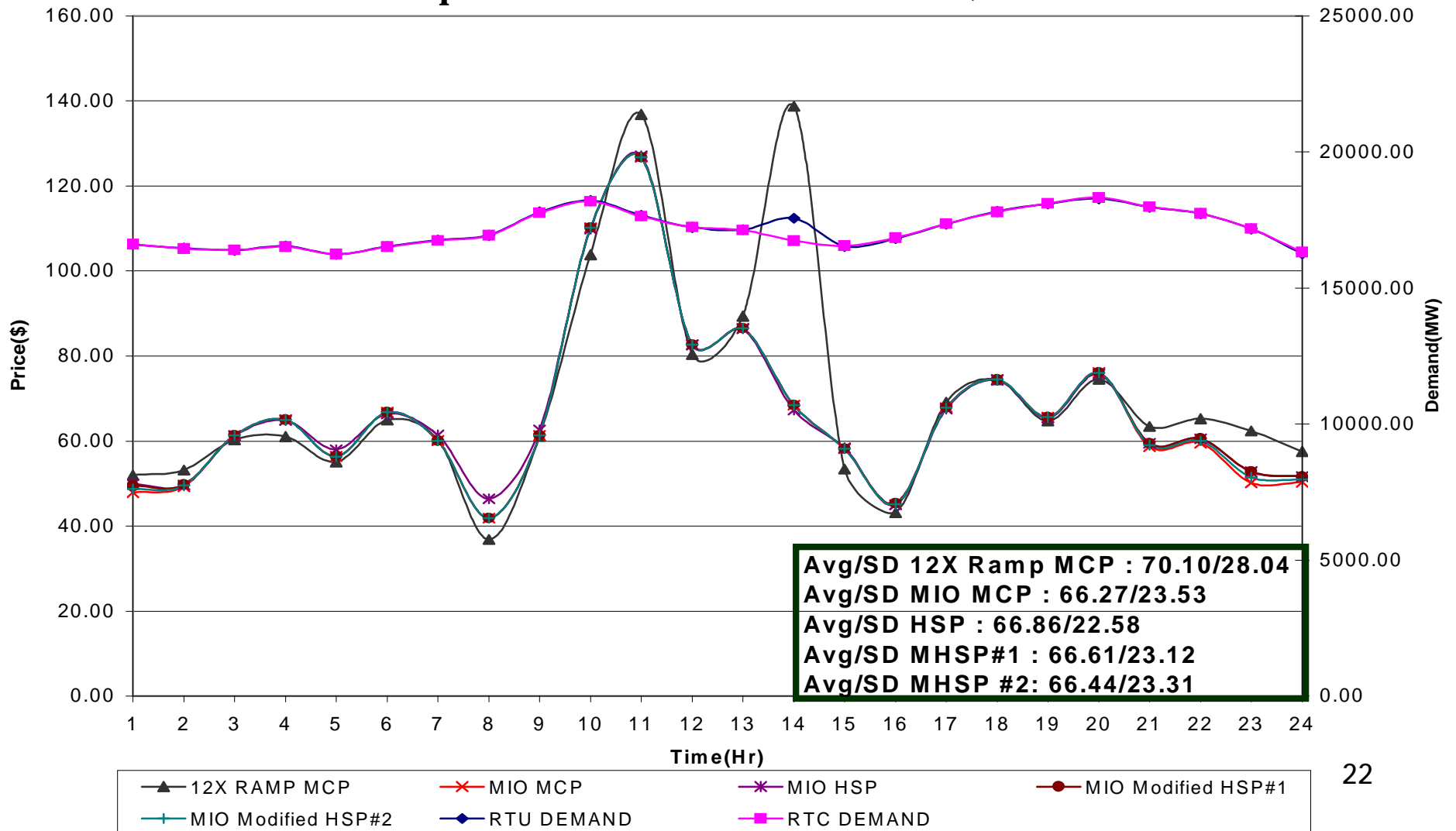
# March Sandbox Simulation Results

**Graph 8. Various Prices for Mar.11, 2005**



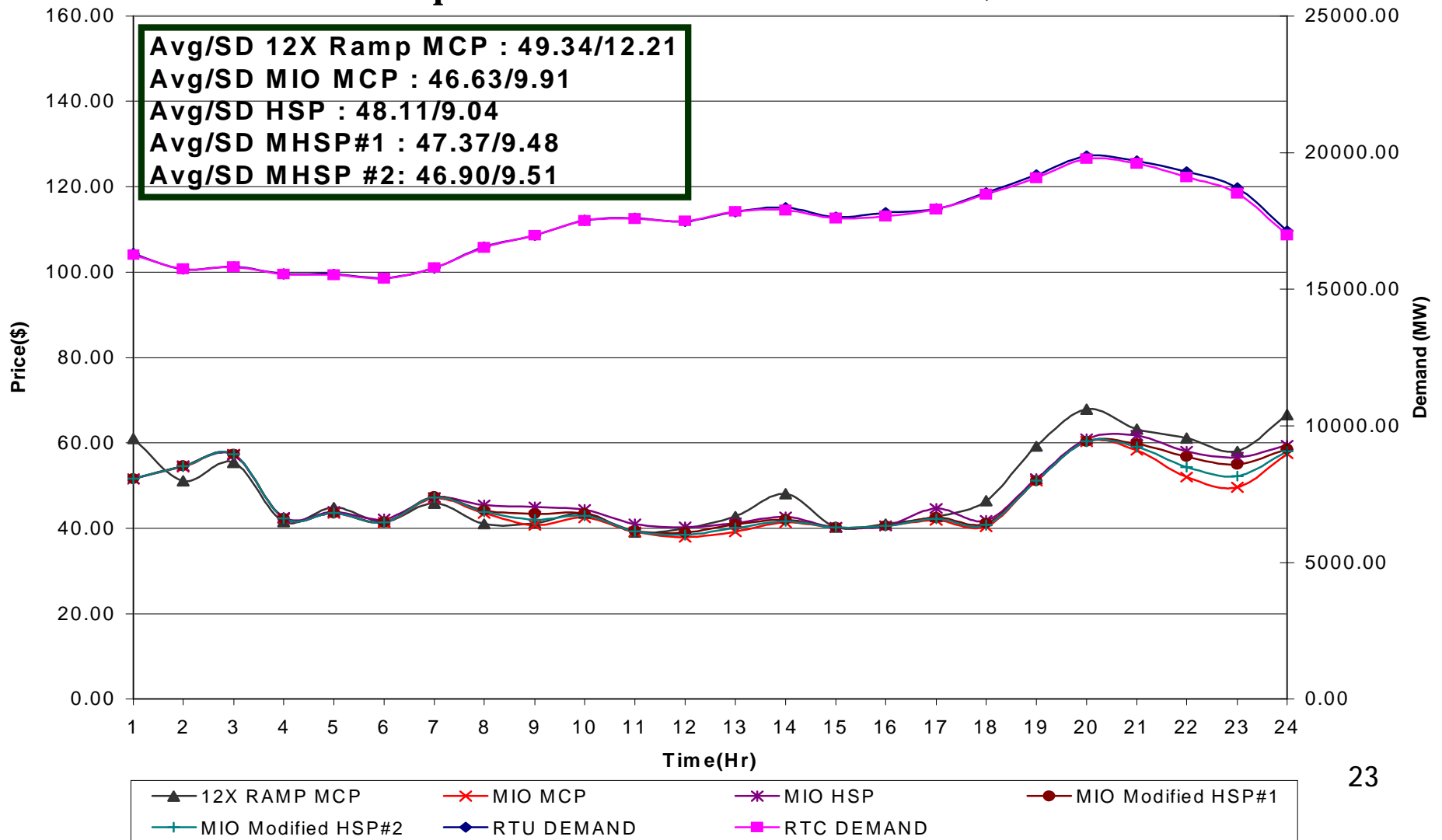
# March Sandbox Simulation Results

**Graph 9. Various Prices for Mar.12, 2005**

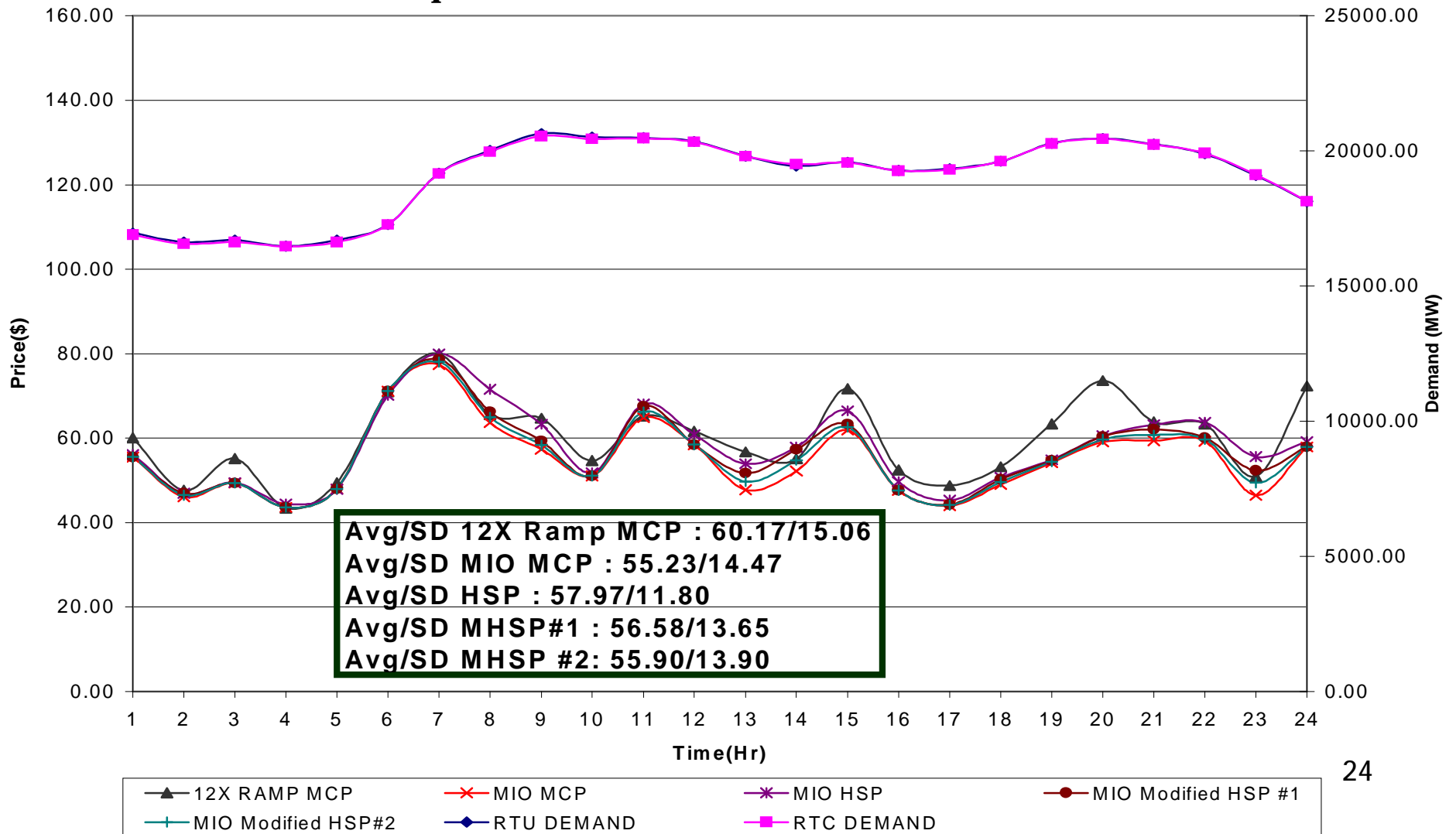


# March Sandbox Simulation Results

**Graph 10. Various Prices for Mar.13, 2005**

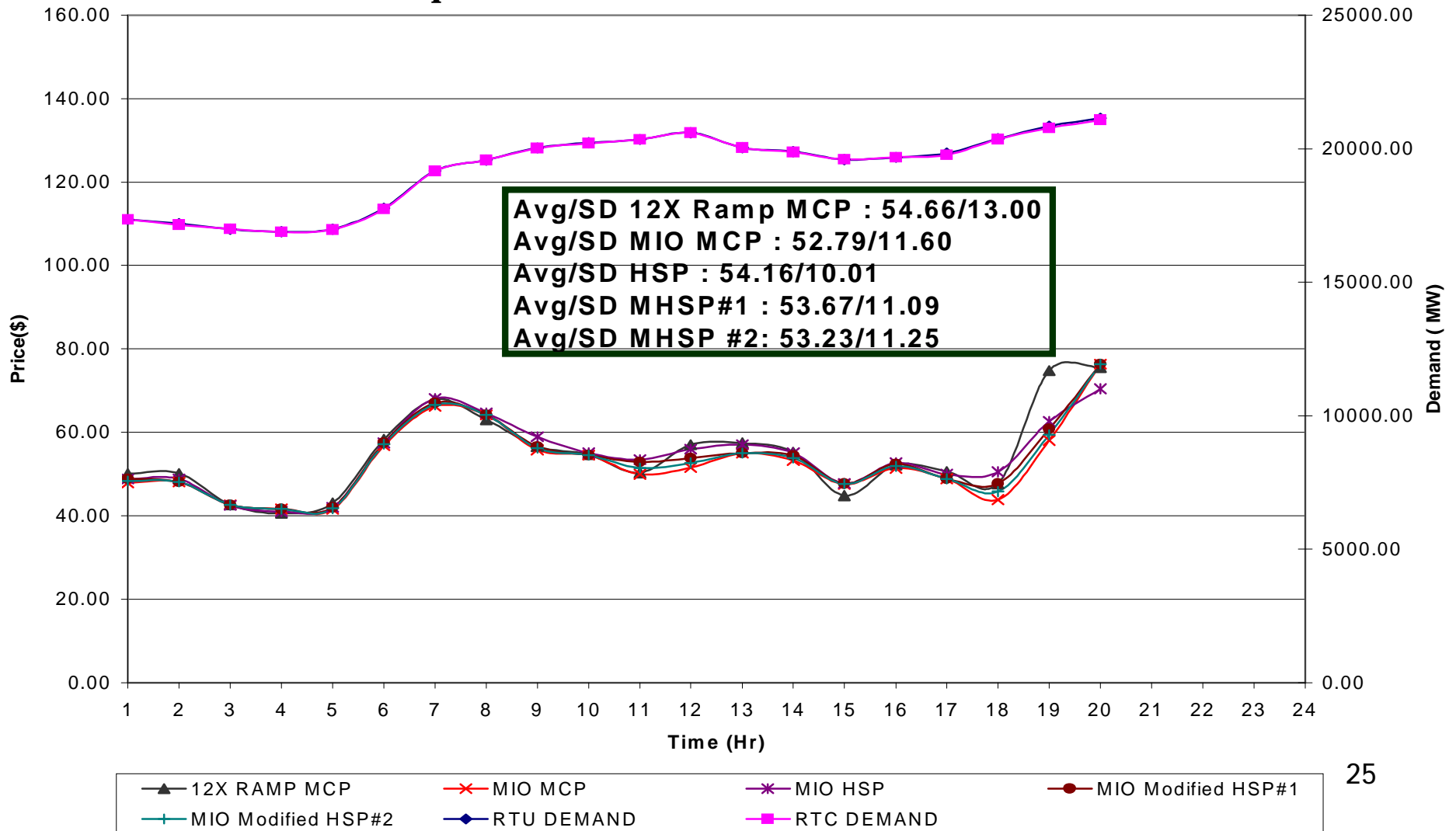


**Graph 11. Various Prices for Mar.14, 2005**



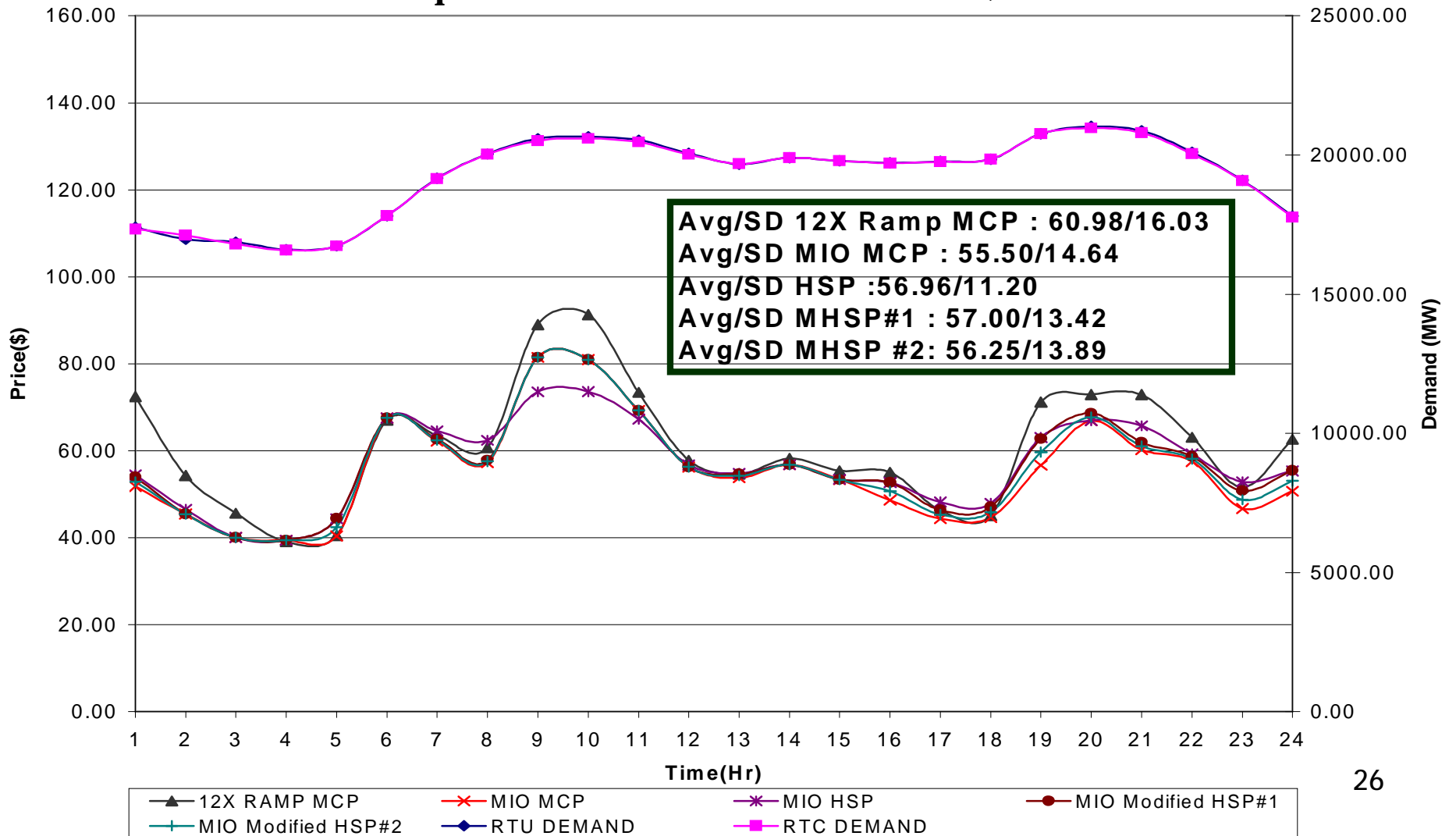
# March Sandbox Simulation Results

**Graph 12. Various Prices for Mar.15, 2005**



# March Sandbox Simulation Results

**Graph 13. Various Prices for Mar.16, 2005**



# Summary of Average Daily Prices

**Table 3. Average Daily Prices**

<b>Date</b>	<b>12X Ramp MCP</b>	<b>MIO MCP (INC.)</b>	<b>MIO HSP</b>	<b>MIO MHSP#1</b>	<b>MIO MHSP#2</b>
<b>Dec.11/04</b>	<b>39.95</b>	<b>39.9</b>	<b>40.93</b>	<b>40.54</b>	<b>39.96</b>
<b>Dec.12/04</b>	<b>55.68*</b>	<b>56.60</b>	<b>56.23</b>	<b>58.19</b>	<b>57.40</b>
<b>Dec.13/04</b>	<b>57.22</b>	<b>58.55</b>	<b>58.95</b>	<b>59.87</b>	<b>59.21</b>
<b>Feb.5/05</b>	<b>45.00*</b>	<b>47.90</b>	<b>51.61</b>	<b>49.25</b>	<b>48.58</b>
<b>Feb.6/05</b>	<b>42.86*</b>	<b>43.09</b>	<b>45.36</b>	<b>43.91</b>	<b>43.50</b>
<b>Feb.7/05</b>	<b>46.07</b>	<b>45.79</b>	<b>47.41</b>	<b>46.58</b>	<b>46.19</b>
<b>Mar.11/05</b>	<b>72.16</b>	<b>72.18</b>	<b>73.46</b>	<b>72.93</b>	<b>72.56</b>
<b>Mar.12/05</b>	<b>67.10*</b>	<b>66.27</b>	<b>66.86</b>	<b>66.61</b>	<b>66.44</b>
<b>Mar.13/05</b>	<b>47.00*</b>	<b>46.63</b>	<b>48.11</b>	<b>47.37</b>	<b>46.90</b>
<b>Mar.14/05</b>	<b>60.17</b>	<b>55.23</b>	<b>57.97</b>	<b>56.58</b>	<b>55.90</b>
<b>Mar.15/05</b>	<b>54.66</b>	<b>52.79</b>	<b>54.16</b>	<b>53.67</b>	<b>53.23</b>
<b>Mar.16/05</b>	<b>55.98<sup>^</sup></b>	<b>55.50</b>	<b>56.96</b>	<b>57.00</b>	<b>56.25</b>
<ul style="list-style-type: none"> <li>• Results were adjusted for large demand differences</li> <li>^ Results were adjusted for tool problems</li> </ul>					27

# Summary of Average Daily Prices

**Table 4. Average Percentage Change in Daily Prices Compared to the 12X Ramp MCP**

<b>Date</b>	<b>MIO MCP (INC.)</b>	<b>MIO HSP</b>	<b>MIO MHSP#1</b>	<b>MIO MHSP#2</b>
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<b>Dec.12/04</b>	<b>2.77</b>	<b>0.99</b>	<b>4.51</b>	<b>3.09</b>
<b>Dec.13/04</b>	<b>2.32</b>	<b>3.01</b>	<b>4.63</b>	<b>3.48</b>
<b>Feb.5/05</b>	<b>6.44</b>	<b>14.68</b>	<b>9.44</b>	<b>7.96</b>
<b>Feb.6/05</b>	<b>0.54</b>	<b>5.83</b>	<b>2.45</b>	<b>1.49</b>
<b>Feb.7/05</b>	<b>-0.61</b>	<b>2.91</b>	<b>1.12</b>	<b>0.25</b>
<b>Mar.11/05</b>	<b>0.03</b>	<b>1.8</b>	<b>1.07</b>	<b>0.55</b>
<b>Mar.12/05</b>	<b>-1.24</b>	<b>-0.36</b>	<b>-0.73</b>	<b>-0.98</b>
<b>Mar.13/05</b>	<b>-0.79</b>	<b>2.36</b>	<b>0.79</b>	<b>-0.21</b>
<b>Mar.14/05</b>	<b>-8.21</b>	<b>-3.66</b>	<b>-5.97</b>	<b>-7.10</b>
<b>Mar.15/05</b>	<b>-3.42</b>	<b>-0.91</b>	<b>-1.81</b>	<b>-2.62</b>
<b>Mar.16/05</b>	<b>-0.86</b>	<b>1.75</b>	<b>1.82</b>	<b>0.48</b>
<b>Average All Days</b>	<b>-0.37</b>	<b>2.57</b>	<b>1.57</b>	<b>0.53</b>
<b>Average Excluding Feb.5/05 #</b>	<b>-0.91</b>	<b>1.35</b>	<b>0.78</b>	<b>-0.13</b>
<b># Problems associated with Feb.5/05 were discussed at MPWG meeting #15</b>				