If ramp constraints are removed from the settlement price, the question remains, should there be additional compensation for providing the ability to respond to changing demand in the market? If so, how much compensation is appropriate and who should receive the compensation?

Some participants have expressed that the current CMSC calculation will compensate ramping participants if their offer price is above the 12X price, but only up to their offer price. They feel that this is not a sustainable situation. There must be some provision beyond marginal cost to allow for adequate returns.

AMPCO provided a proposed solution in their discussion paper for the March 3 MPWG meeting. The proposal suggested a means for determining both how much should be paid for ramp, and to whom. AMPCO proposed that a payment should be made to generators that provide ramp during a “ramp limited event”. A ramp limited event occurs for intervals where a ramp limited price would be different than a non ramp limited price. During the event, the value of ramp should be based on the difference between a ramp limited price and a non ramp limited price during any given interval. They also proposed that this ramp value should be paid to generators for any change in their market schedule from the first interval of the ramp limited event through to the end of the event (when both prices are equal).

Some of the participants at the March 3, 2006 MPWG meeting expressed that any payment must be on the constrained dispatch, not the unconstrained schedule. They felt the payment must be tied to ramp which is actually delivered and that using the unconstrained as the basis would sometimes mean not paying for delivered ramp as well as paying for ramp not delivered.

There are also issues harmonizing the ramp payment with CMSC. Finally, the comparison of output to the output at the start of ramp limited event, rather than interval by interval is more complex from a settlement point of view, and can lead to different payments for generators that ramp at the start of an event than for generators who provide the same ramp at the end of an event.

This discussion paper presents a modified method for providing a ramp payment to ramping generators. While the goal of proving a ramp supplement remains the same, the calculation method is slightly different.

Ramp Constrained Settlement Credit

Calculating a payment for generators that provide ramp means determining how much to pay, and to which generators. It is proposed to make a payment based upon the change in dispatch quantity from one interval to the next.

$$Payment_i = Function (DQSI_i – DQSI_{i-1})$$

The next step involves determining the appropriate amount to pay for each megawatt of ramping service. Because there is no market for ramp at this point in time, and no way for participants to specifically offer their ability to ramp at a given price, it is difficult to determine a market based price for ramp. The AMPCO approach suggests that the value of ramp is evident when it is in short supply.

Because all dispatchable participants can and must provide ramp in order to deliver their product to market, there is a basic amount of ramp built into the energy market. It is only when this ramp amount is insufficient to match the change in the demand – supply mix that there is a premium for the ability to ramp. AMPCO suggests this premium can be found by comparing two unconstrained prices;

- a base price where there is no ramp constraints
- a ramp constrained priced where the algorithm includes ramp constraints

When the ramp constrained price is different than the base price, the difference represents the value of ramp to be paid to participants responding to restore the demand – supply balance.

$$Payment_i = Function (RCP_i – MCP_i)$$

where:

- RCP_i is a ramp constrained price in interval *i*,
- MCP_i is the non ramp constrained price in interval *i*,

<u>Ramp Payment</u>

The ramp payment must compensate the ramping unit beyond their offer price, up to the price based on the ramp constrained price calculation, RCP_i

$$Ramp\ Constraint\ Settlement\ Credit = (DQSI_i – DQSI_{i-1}) x (RCP_i – Offer)$$

Where RCP_i is the ramp constrained price in interval *i*

<u>CMSC</u>

The CMSC (Congestion Management Settlement Credit) calculation already compensates participants who are physically ramping if their offer price is above the market clearing price. This compensation is capped at the offer price. The ramp payment can be combined with CMSC to reward ramping participants for their contribution to the market.

CMSC for interval *i*

$OP(MQSI_i) – OP(DQSI_i)$
where

- OP is operating profit which is defined for a generator as (MCP_i – offer)
- $MQSI_i$ is the unconstrained market schedule in interval *i*
- $DQSI_i$ is the constrained dispatch in interval *i*
- MCP_i is the unconstrained, base price with no ramp limitation in interval *i*,

Therefore, CMSC for a generator during interval *i* is:

$$(MQSI_i – DQSI_i) \times (MCP_i – Offer)$$

RCSC and CMSC

A simple example will demonstrate how the RCSC (Ramp Constrained Settlement Credit) and CMSC would work together.

Generator A offers 100 MW into the market at $75/MWh with a ramp rate of 4 MW/min

In interval 5, Generator A is setting price at $75 with an output of 50 MW. During interval 5, both the market schedule and dispatch for generator A is 50 MW.

In interval 6 market demand rises by 40 MW from the demand in interval 5.

The 12X base price remains $75 as the non ramp constrained price assumes Generator A increases output to 90 MW
A second run of the unconstrained algorithm however sees that Generator A cannot satisfy demand because of ramp limitations and produces a ramp constrained price of
$ 90/MWh.

Generator A receives a market schedule of 90 MW and a dispatch instruction of 70 MW.

CMSC for interval 6

CMSC = (MQSI – DQSI) x (MCP – offer)
= (90 – 70)/12[1] x ($75 - $75)
= 0

RCSC for interval 6

RCSC = ($DQSI_i - DQSI_{i-1}$) x (RCP_i – Offer)
= (70 – 50)/12 x (90 – 75)
= $25

Similarly, if a generator is constrained on and ramping for transmission limitations, it will attract an RCSC. Consider a simple example.

Generator B offers 100 MW into the market at $95/MWh with a ramp rate of 4 MW/min

In interval 5 both the base price and the ramp constrained price is $75. Generator B has been constrained on to 50 MW.

In interval 6 market demand rises by 40 MW from the demand in interval 5. Generator B is dispatched to increase its' output by 20 MW to 70 MW.

The base price remains $75 as the unconstrained schedule has adequate supply available, however the ramp constrained price rises to $115/MWh

[1] Quantities expressed are in MW while payment is per MWh. A five minute interval represents 1/12th of an hour. To convert MW to MWh, we must divide by 12. e.g. generating 120 MW for one hour produces 120MWh, generating 120 MW for five minutes produces 10 MWh.

CMSC for interval 6

CMSC = (MQSI – DQSI) x (MCP – offer)
= (0 – 70)/12 x ($75 - $95)
= -5.83 x - $15
= $87.50

RCSC for interval 6

RCSC = ($DQSI_i$ – $DQSI_{i-1}$) x (RCP_i – Offer)
= (70 – 50)/12 x (115 – 95)
= $33.33

Adjustment for Actual Output

The CMSC is adjusted based on meter data so that no CMSC is provided for MW not produced, or for overproduction in a constrained on situation. The CMSC calculation for any given interval includes an adjustment for actual output based on the meter reading.

CMSC = OP (MQSI/W) - MAX [OP (DQSI/W), OP (AQEI/W)]

where AQEI represents the allocated quantity of energy injected as provided from the settlement ready data.

Similarly, we can adjust the payment made for the RCSC (Ramp Constraint Settlement Credit) to only pay for ramp that is actually delivered

RCSC = (RCP_i – Offer) X Min[($DQSI_i$ – $DQSI_{i-1}$),($AQEI_i$-$AQEI_0$)]

Looking at our previous example, suppose that Generator A fails to meet it's dispatch of 70 MW, but instead only provides 60 MW. They should not be compensated for the missing 10 MW.

CMSC = OP (MQSI/W) - MAX [OP (DQSI/W), OP (AQEI/W)]

For a generator OP = Quantity x (MCP – offer)

CMSC = (MQSI x (MCP – offer) – MAX (DQSI x (MCP – offer), AQEI x (MCP – offer)

In this example, MCP and offer are both $75, so there is no CMSC. There is however a ramp constraint payment.

RCSC = (RCP_i – Offer) X Min[($DQSI_i$ – $DQSI_{i-1}$),($AQEI_i$-$AQEI_0$)]

RCSC = ($90 - $75) x MIN [(70 – 50)/12, (60 – 50)/12]
RCSC = ($15 x 10/12)
= $12.50

Dispatchable Loads

Dispatchable loads also receive dispatch instructions, have ramp rates and can alleviate or exacerbate ramp limitations on the system. It seems reasonable that a load which is moving to alleviate a ramp constraint should be eligible for a ramp payment.

In the case of a load, the CMSC formula is changed to recognize their different operating profit. Operating profit is the difference between revenue and cost. For a generator revenue is MCP and cost is deemed to be the offer price. For a load, revenue is deemed to be the bid, and cost is the MCP. There is an analogous situation for the RCSC.

For a load, the appropriate response to a ramp constraint is the opposite from a generator. During a ramp up limitation, a load should be rewarded for ramping down. So payment should be based upon:

$(DQSW_{i-1} – DQSW_i)$

The value of the ramp per MW is, however, the same as the value for a generator. In this case it is bid less the ramp constrained price or $(RCP_i – Bid)$

A simple example can illustrate how a dispatchable load might be paid.

A dispatchable load bids 100 MW into the market at $100 starting at 9 am with a ramp rate of 2 MW/min. The market has been clearing at $75 and the facility has been consuming 100 MW of energy. During interval 5, the unconstrained clearing price remains $75 however both the ramp constrained price and the dispatch price increase.

The constrained price increases to $150 and the constrained schedule dispatches the load off.

The ramp constrained price is $120

$MQSW_5 = 100$
$DQSW_4 = 100$
$DQSW_5 = 90$

In interval 5

CMSC = (MQSW – DQSW) x (Bid – MCP)
= (100 – 90)/12 x (100 – 75)
= $204

RCSC = $(DQSW_{i-1} – DQSW_i)$ x $(RCP_i – Bid)$
= (100-90)/12 x (120 -100)
= $16.6

Should RCSC Cash Flow be Two Way?

There are situations which can lead to a negative RCSC. Since the RCP is generated from the unconstrained algorithm, it is still possible that the constrained algorithm may need to dispatch generators with offers higher than the RCP due to transmission limitations. This can create a situation where a generator is ramping up with demand, but has an offer price above the ramp constrained price. A simple example will illustrate the situation.

In interval 5 of the hour, the unconstrained MCP is $60. The ramp constrained price is $80 and the generator offer is $100. Due to transmission limits, the unit has been dispatched to increase it's output from 0 to 20 MW. The constrained schedule is zero.

$MQSW_5 = 0$
$DQSW_4 = 0$
$DQSW_5 = 20$
$MCP_5 = \$60$
$RCP_5 = \$80$
Offer = $100

CMSC = (MQSI – DQSI) x (MCP – offer)
= (0 – 20)/12 x ($60 - $100)
= -1.66 x - $40
= $66.40

RCSC = $(DQSI_i – DQSI_{i-1})$ x $(RCP_i$ – Offer)
= (20 – 0)/12 x (80 – 100)
= 1.66 x - 20
= -$33.33

In this case, the RCSC will restore the facility to the ramp constrained price, however this is below their offer price. Any net settlement below the offer price is unacceptable. The RCSC in this situation should be zero rather than a negative.

RCSC = Max{0, {$(RCP_i$ – Offer) X Min[$(DQSI_i – DQSI_{i-1})$,$(AQEI_i$-$AQEI_0)$]]}

This would also prevent dispatchable loads from paying a RCSC charge when ramping up during ramp up price constrained events.

Ramping Down

There is an analogous situation to the ramp up constraints when demand is dropping. In this situation, the ramp constrained price will be below the unconstrained price. Generators with offer prices below the unconstrained price will be constrained off to accommodate the drop in demand.

A simple example will illustrate the situation.

Generator A offers 100 MW into the market at $50 with a ramp rate of 4 MW/min. They have been operating at 100 MW for the past few hours.

The unconstrained, non ramp limited price in interval 5 is $60, however the ramp constrained price has dropped to $20. The constrained algorithm has begun to move Generator A down as higher priced generators cannot ramp down quickly enough to keep pace with the falling demand. The dispatch quantity for interval 5 is 80 MW.

$MQSW_5$ = 100
$DQSW_4$ = 100
$DQSW_5$ = 80
MCP_5 = $60
RCP_5 = $20
Offer = $50

CMSC = (MQSI – DQSI) x (MCP – offer)
= (100 – 80)/12 x ($60 - $50)
= 16.67

RCSC = ($DQSI_i$ – $DQSI_{i-1}$) x (RCP_i – Offer)
= (80 – 100)/12 x (20 – 50)
= -1.66 x - 30
= $50