Tracking Ramp Limited Calculation

MIC

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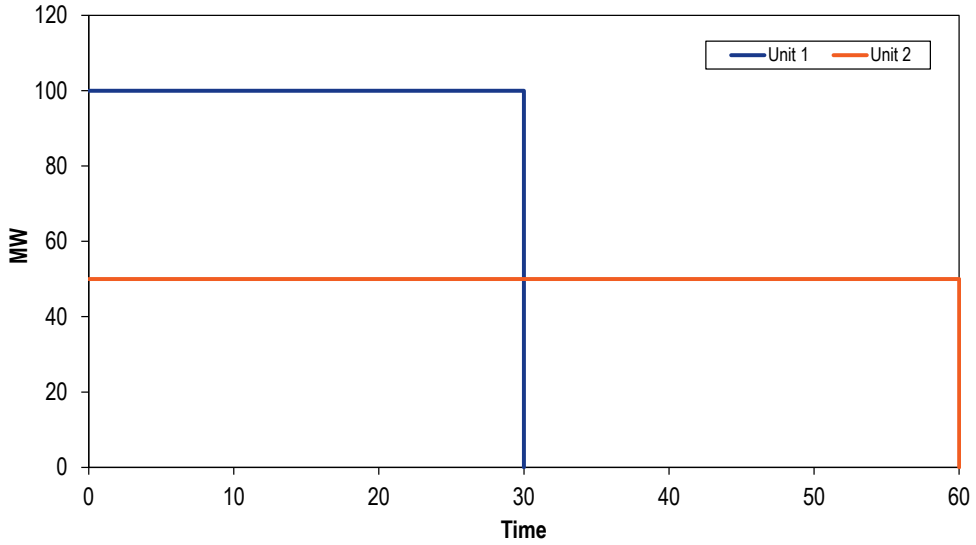
Monitoring Analytics

Power vs Energy

- **Power is the rate at which energy is produced or used.**
  - **Power is measured in watts (W).**
- **Energy is the amount of power used over time.**
  - **Energy is measured in watt-hours (Wh).**

Power vs Energy

- **Unit 1 produces at a rate of 100 MW for 30 minutes.**
- **Unit 2 produces at a rate of 50 MW for 60 minutes.**
- **Both units produce 50 MWh.**



PJM Settlements

- **PJM's energy market settles in energy (MWh).**
- **Generators and load provide hourly or five minute metered energy data via power meter.**
- **The energy data is equal to the amount of power used over the defined time (e.g. an hour or five minutes).**

Following Dispatch Metrics

- **PJM has been measuring how well units follow dispatch by comparing an energy metric to a power metric.**
- **DA generation is equal to the amount of power produced over an hour (energy).**
- **RT generation is equal to the amount of power produced over an hour or over five minutes (energy).**
- **Operating Reserve Desired MW is a power metric. It represents the desired output at an specific point in time.**

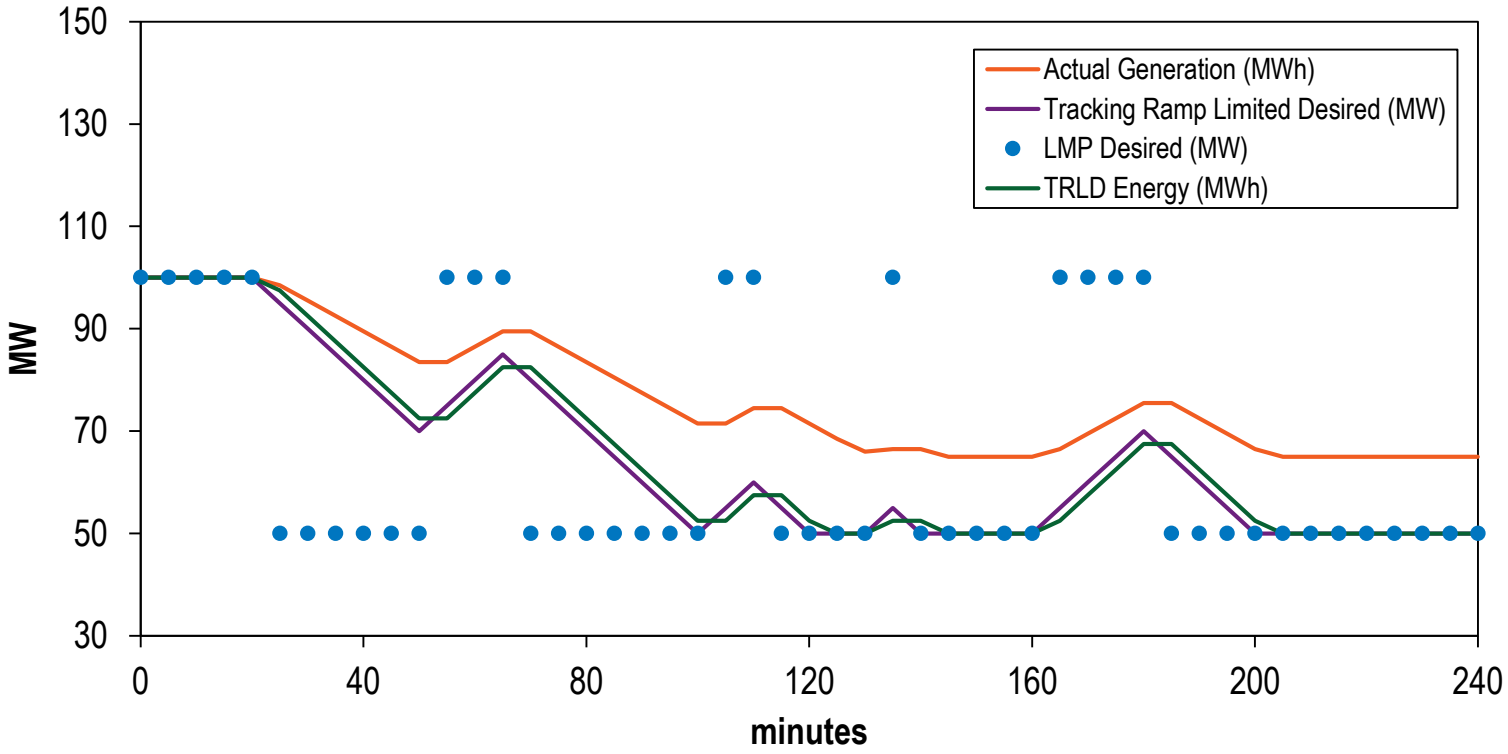
Operating Reserve Desired MW Recap

- **Operating Reserve Desired MW is the term used for the desired MW value used in the Operating Reserve make whole credit calculation (as well as in the deviation charge calculation). The Operating Reserve Desired MW can be:**
  - **Ramp-limited Desired (RLD): Output level that a resource should have achieved between dispatch signals.**
  - **Dispatch signal MW or Basepoint MW: Output level requested via the dispatch basepoint issued by PJM's real-time dispatch tools.**
  - **Dispatch LMP Desired: Output level based on the dispatch run LMP and the incremental offer curve. This value is not ramp limited.**

TRLD Energy

- **With the introduction of Tracking Ramp Limit Desired (TRLD) MW, PJM and the IMM are also proposing to make the comparison between DA/RT generation and TRLD consistent.**
- **TRLD MW (power metric) will be calculated as it has been explained but each five minute value will be used to calculate the amount of power produced over five minutes.**
- **TRLD Energy$_i$ = (TRLD$_t$ + TRLD$_{t+1}$) / 2**
  - **Where t is the SCED target time**
  - **Where i is the 5 minute interval beginning at t**

Example


150
130
110
90
70
50
30
MW
0
40
80
120
160
200
240
minutes
Actual Generation (MWh)
Tracking Ramp Limited Desired (MW)
LMP Desired (MW)
TRLD Energy (MWh)

First Hour of Example

Target Time	Initial MW	Dispatch Signal MW	TRLD Power MW	Settlement Interval Beginning Time	Settlement Interval Ending Time	TRLD Energy MWh	Energy MWh
0:00	100	100	100				
0:05	100	100	100	0:00	0:05	100	100
0:10	100	100	100	0:05	0:10	100	100
0:15	100	100	100	0:10	0:15	100	100
0:20	100	100	100	0:15	0:20	100	100
0:25	100	95	95	0:20	0:25	97.5	98.5
0:30	97	92	90	0:25	0:30	92.5	95.5
0:35	94	89	85	0:30	0:35	87.5	92.5
0:40	91	86	80	0:35	0:40	82.5	89.5
0:45	88	83	75	0:40	0:45	77.5	86.5
0:50	85	80	70	0:45	0:50	72.5	83.5
0:55	82	87	75	0:50	0:55	72.5	83.5
1:00	85	90	80	0:55	1:00	77.5	86.5
					Hourly Values	88.3	93.0

- **For example, in the interval between 0:20 and 0:25, the unit is expected to be at 100 MW at 0:20 and at 95 MW at 0:25 (unit has a 1 MW per minute ramp rate). The expected energy equals 97.5 MWh (divided by 12, 12 five minute intervals in one hour).**

TRLD Energy

- **TRLD Energy will be used to calculate the amount of uplift necessary if the unit had followed dispatch.**
- **TRLD Energy will be compared to RT Generation to assess deviations when desired MW is used today for deviations.**

Tracking Ramp Limited Desired Recap

- **The TRLD MW proposed solution would replace all desired MW values in the calculation of operating reserve credits.**
  - **Simplifies the calculation.**
  - **More accurately measures how closely a resource is following dispatch over a period of time compared to status quo.**
  - **Acknowledges ramping limitations better than the LMP Desired MW value that is currently used when resources are significantly deviating.**

Calculation

- **The start and end of the TRLD calculation will be triggered by the effective time of the energy dispatch logs (regardless of whether it is a pool or self-scheduled energy log).**
- **The starting point of the TRLD calculation will depend on the type of log.**
  - **Units that are requested to be dispatchable at an specific time.**
  - **Units that are requested to start immediately.**
- **The starting point trigger will be the effective time of the first energy log after the unit has been offline.**
  - **Subsequent logs, after the unit is online, will not trigger a restart of the TRLD calculation.**

TRLD Starting Point Calculation

Log Type	Start of TRLD Calculation (t_0)	Description
Requested to be dispatchable at a specific time t_0 = Time at which log becomes effective	$TRLD_{t0}$ = MAX [MIN [LMP Desired , SCED Basepoint] , Eco Min]	The first TRLD to be calculated will be between Eco Min and SCED Basepoint (capped at LMP Desired in case the unit is overgenerating). After t_0, TRLD will ramp the unit up, down or remain equal based on the LMP.
Requested to start immediately t_0 = min(Time requested + Notification Time + Start Time, time unit comes online)	$TRLD_{t0}$ = 0 MW	After t_0, TRLD will ramp the unit up until it reaches eco min. After TRLD reaches eco min, TRLD will ramp the unit up, down or remain equal based on the LMP.

Examples:

- **PJM calls a unit at 11:00 to be dispatchable by 15:00. t_0 = 15:00.**
- **PJM calls a unit with a 30 minute time to start at 11:00 to start immediately, t_0 = 11:30.**

Before Starting Point Calculation

- **Before t_0:**
  - **TRLD Energy will be equal to RT MWh.**
  - **No deviations will be assessed.**
- **If unit starts late, deviations will be assessed.**
- **If unit starts early:**
  - **When the unit is requested to be dispatchable: t_0 will reflect the early commitment when the unit gets logged.**
  - **When the unit is requested to start immediately, t_0 will reflect the time the unit started.**

TRLD During Commitment

- **During commitment the unit will be dispatched based on the SCED (Dispatch Run) LMP.**
  - **$TRLD_t = TRLD_{t-1}$ +/- $Ramp_t$**
  - **Where Ramp equals:**
    - When $LMP\ Desired_t > TRLD_{t-1}$, Ramp = MIN(Up Ramp Rate x 5 minutes, $LMP\ Desired_t - TRLD_{t-1}$)
    - When $LMP\ Desired_t < TRLD_{t-1}$, Ramp = MIN(Down Ramp Rate x 5 minutes, $TRLD_{t-1} - LMP\ Desired_t$)
    - Capping the Ramp term at ($LMP\ Desired_t - TRLD_{t-1}$) ensures that the calculated TRLD does not exceed the LMP Desired.
    - LMP Desired equals the point on the incremental energy offer curve equal to the dispatch run LMP, bounded by eco min and eco max.

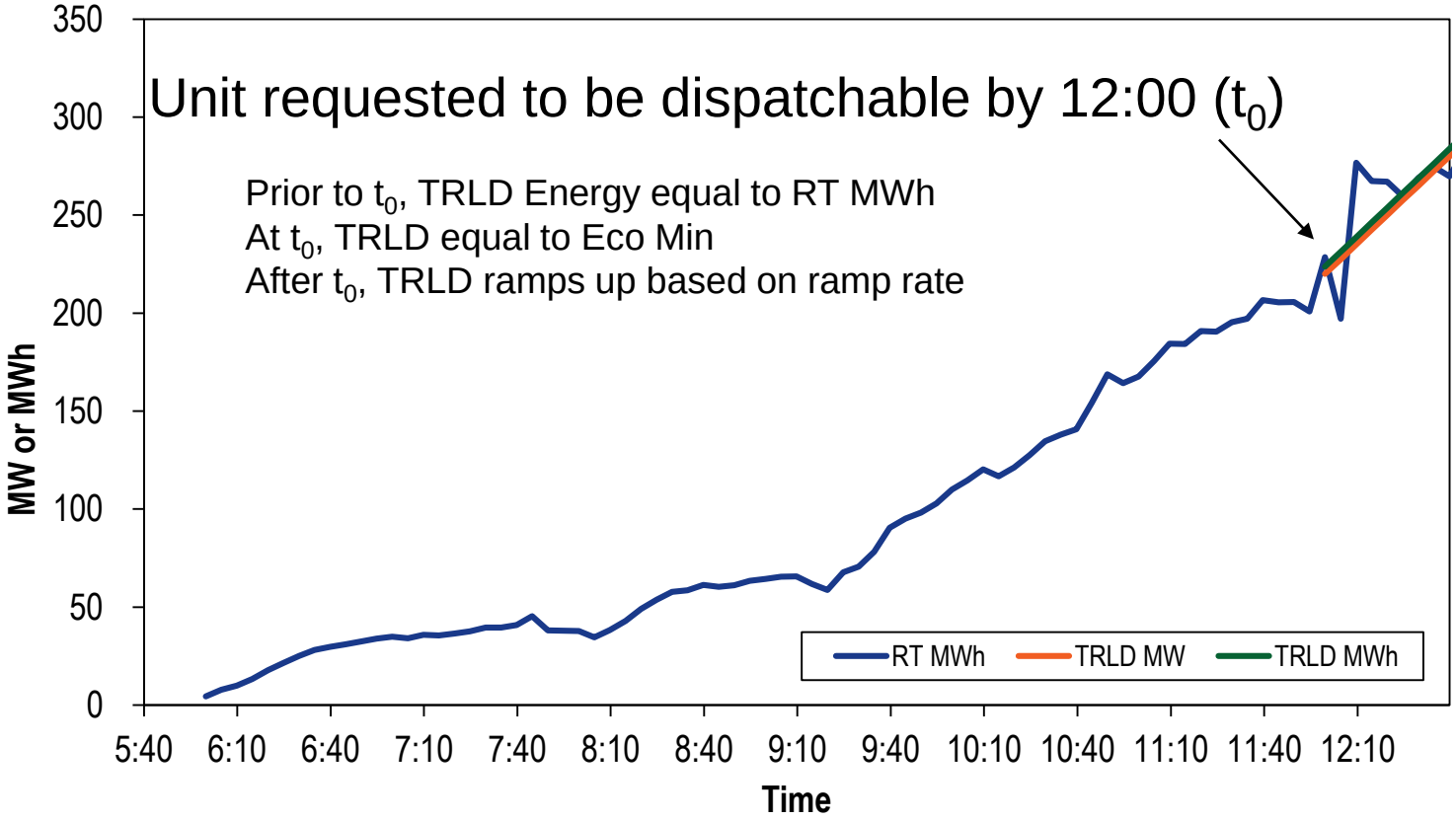
TRLD After Released

- **After commitment (i.e. unit is released) the assumption is that the unit will be dispatched down to eco min. Once TRLD reaches Eco Min, the calculation will use the lower of TRLD and RT MWh since PJM does not have ramp down MW profile.**

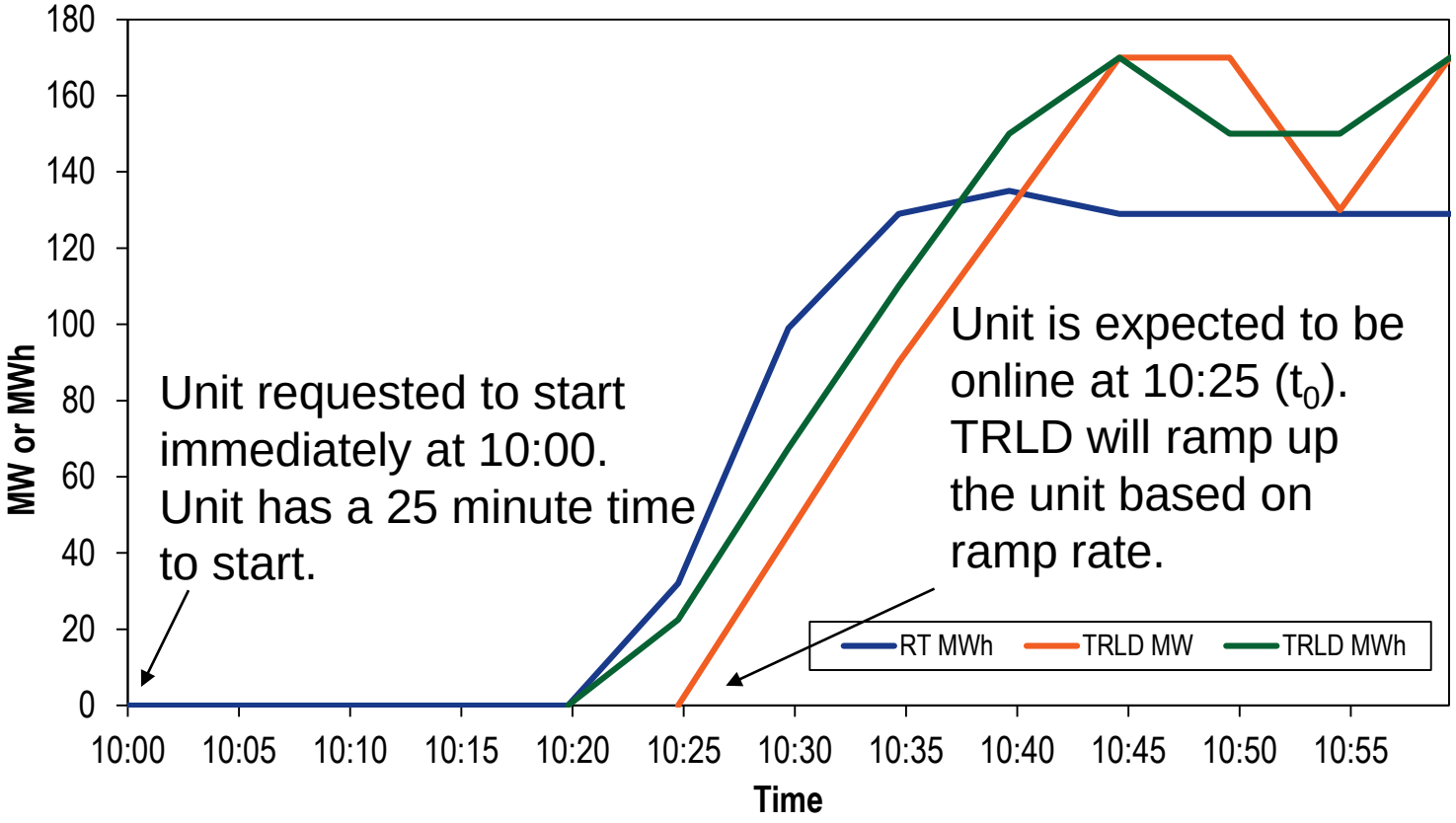
$$TRLD_t = MAX [TRLD_{t-1} - Down\ Ramp , Eco\ Min]$$

$$TRLD\ Energy_i = MIN [(TRLD_t + TRLD_{t+1}) / 2 , RT\ MWh)$$

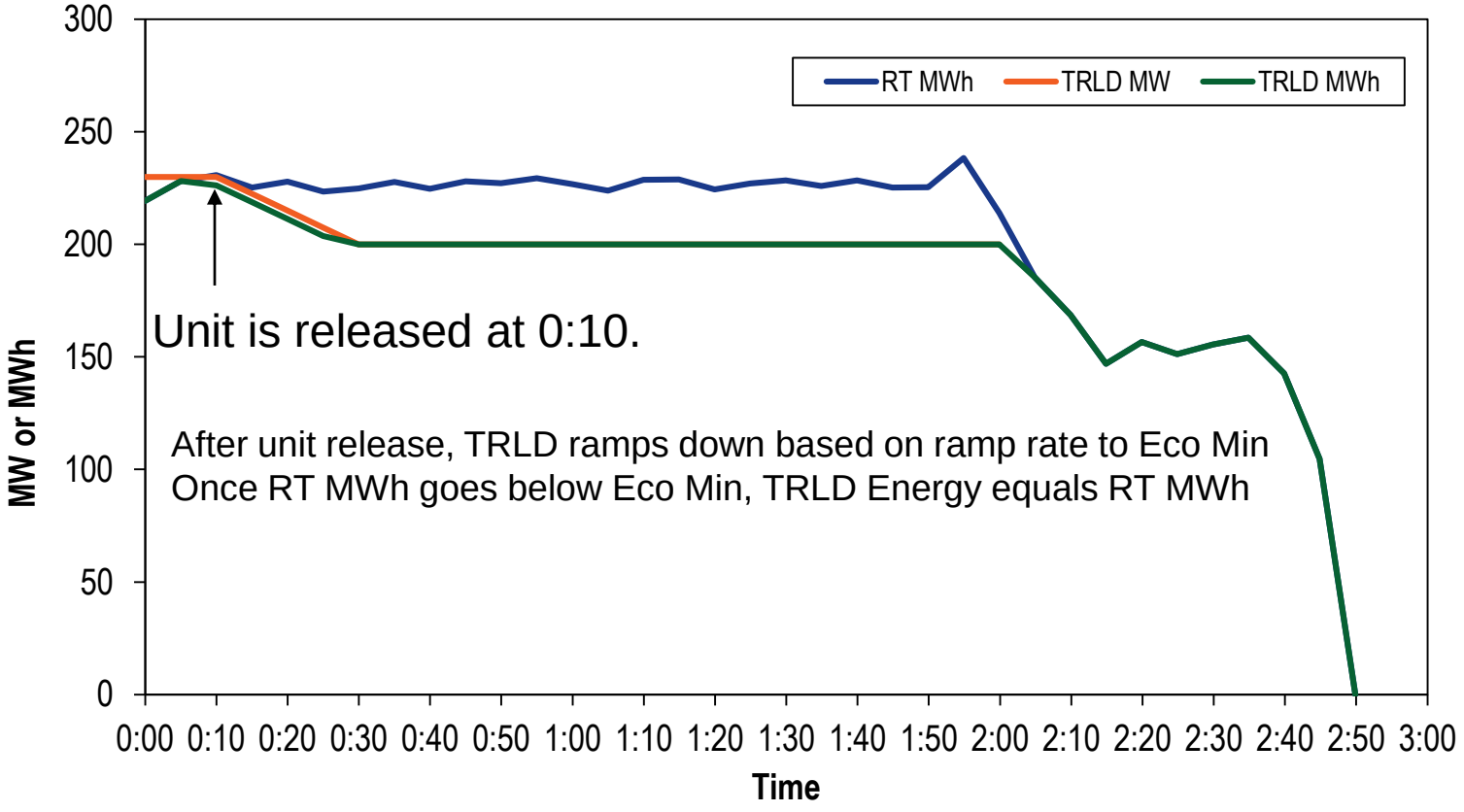
Starting Point Example



Starting Point Example



Released Example



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