

Operating Parameter Definitions

Minimum Run Time Problem

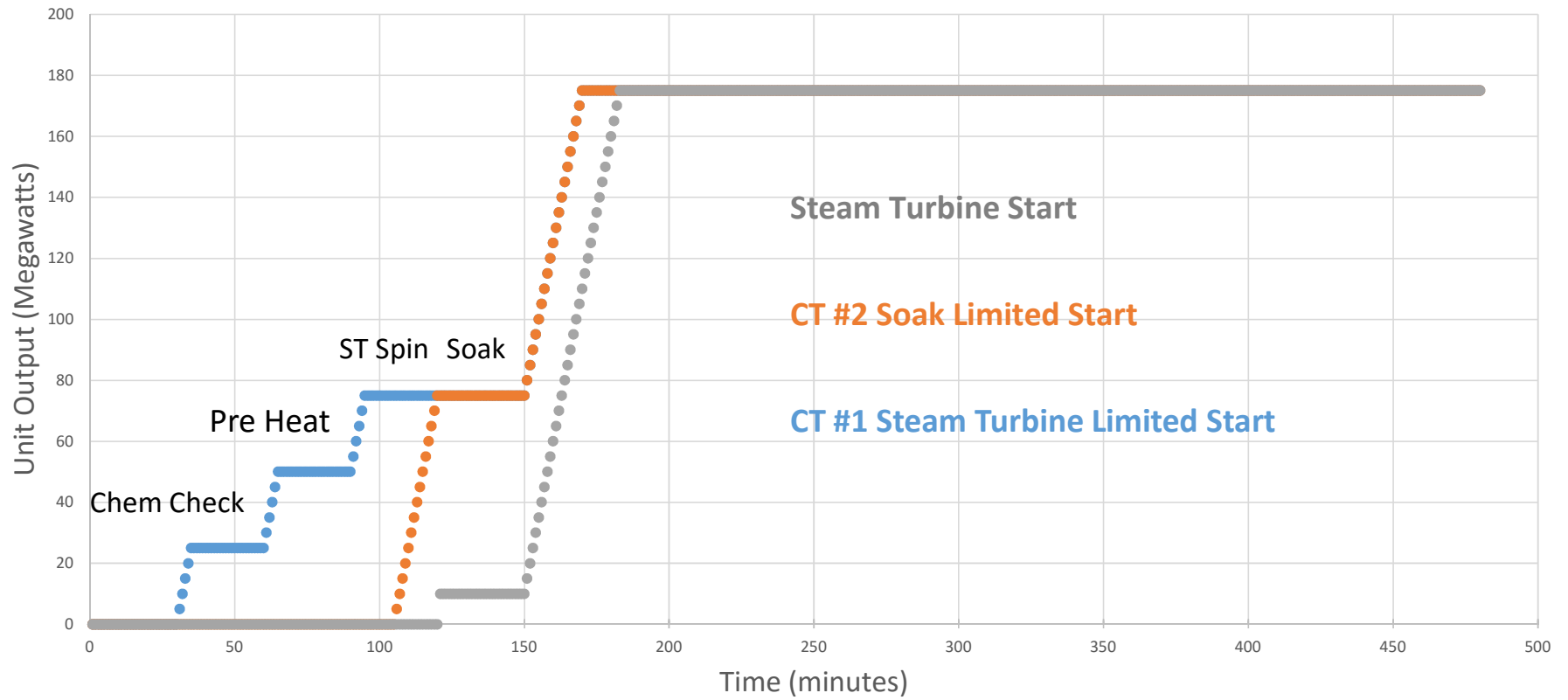
Minimum Run Time Proposed Definition

The minimum number of hours a unit must run, in real-time operations, from the time of generator breaker closure to the time of generator breaker opening (as measured by PJM's state estimator). **For Combined Cycle units this is the time period between the first combustion turbine generator breaker closure and the steam turbine generator breaker opening.**

Start Phases

- Chem Check
 - Circulating and heating water in HRSG
 - Waiting to remove impurities water/steam
 - Minimizes impurities in steam that can pit steam turbine blades
 - Requires more time for cold starts in winter because of anti-freeze chemicals
- Pre Heat
 - Heating steam turbine and drawing vacuum in steam turbine
 - Limits rate of change of temperature to acceptable levels
- ST Spin
 - Increasing speed of steam turbine at acceptable rate
- Soak
 - Stabilizing units
 - Heating steam turbine to normal operating temperatures

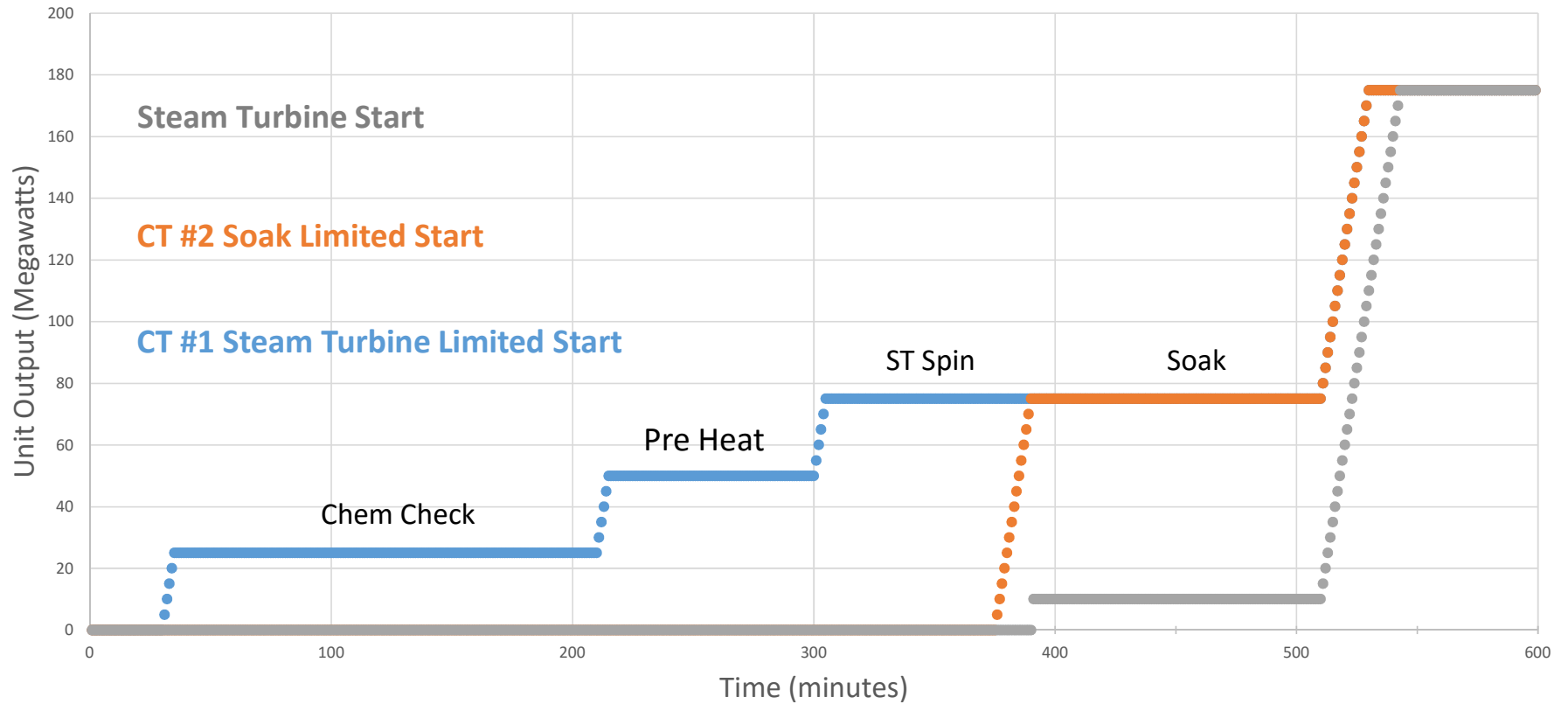
Combined Cycle Hot Start



Typical Hot Start Values

- CT Start – 30 minutes
- Chem Check – 30 minutes
- Pre Heat – 30 minutes
- ST Spin – 30 minutes
- Soak – 30 minutes
- Values differ depending on design

Combined Cycle Cold Start



Typical Cold Start Values

- CT Start – 30 minutes
- Chem Check – 180 minutes
- Pre Heat – 90 minutes
- ST Spin – 90 minutes
- Soak – 120 minutes
- Values differ depending on design

Dispatch Time

- Demonstrative Metric to highlight issue
- Dispatch Time is the difference between Minimum Run Time and the sum of the Chem Check, Pre Heat, ST Spin, and Soak times
- Assume a Minimum Run Time of 480 minutes
 - If unit is in a hot condition, Dispatch Time equals
 - $480 - (30 + 30 + 30 + 30) = 360$ minutes
 - If unit is in a cold condition, Dispatch Time equals
 - $480 - (180 + 90 + 90 + 120) = 0$ minutes

Minimum Run Time Potential Solutions

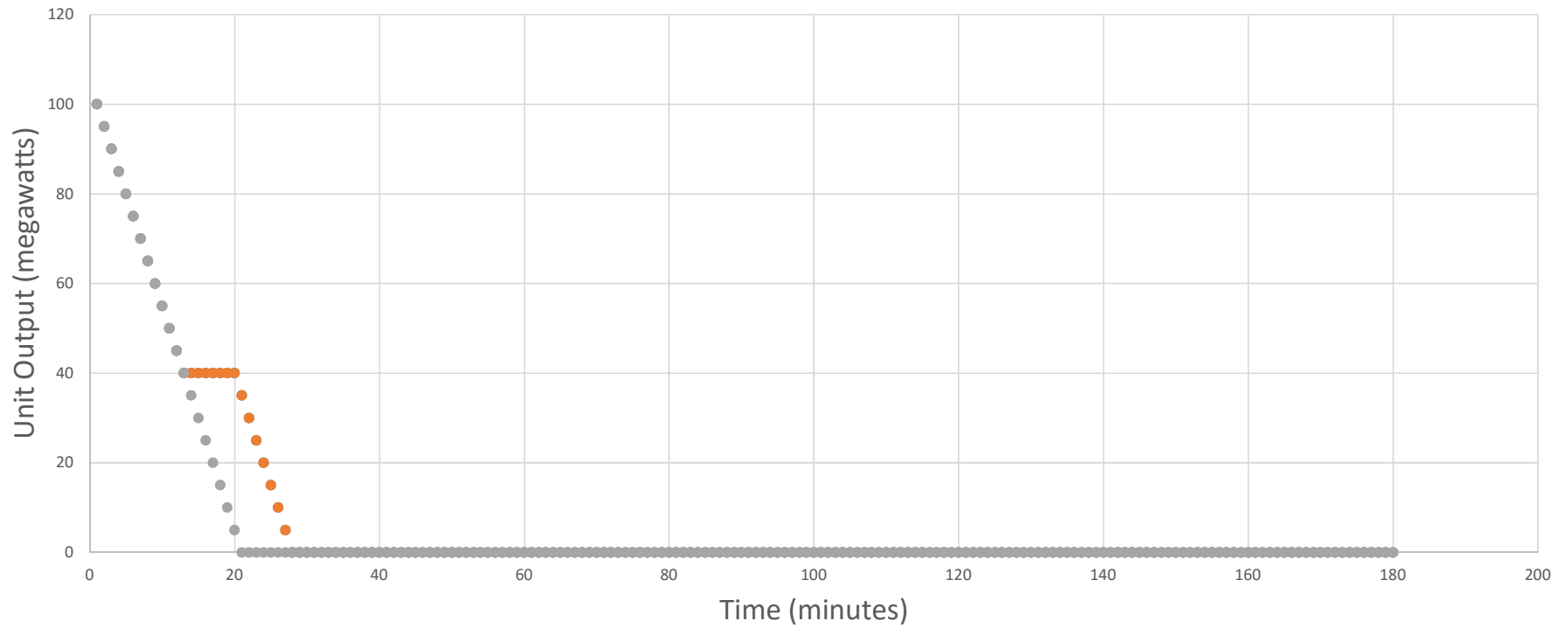
- Un-nest Parameters
 - Soak Time must have three condition dependent values
 - Hot
 - Warm
 - Cold
 - Begin Minimum Run Time at the end of Soak Time
 - Add condition dependent Minimum Run Time
 - Hot
 - Warm
 - Cold

Minimum Down Time Problem

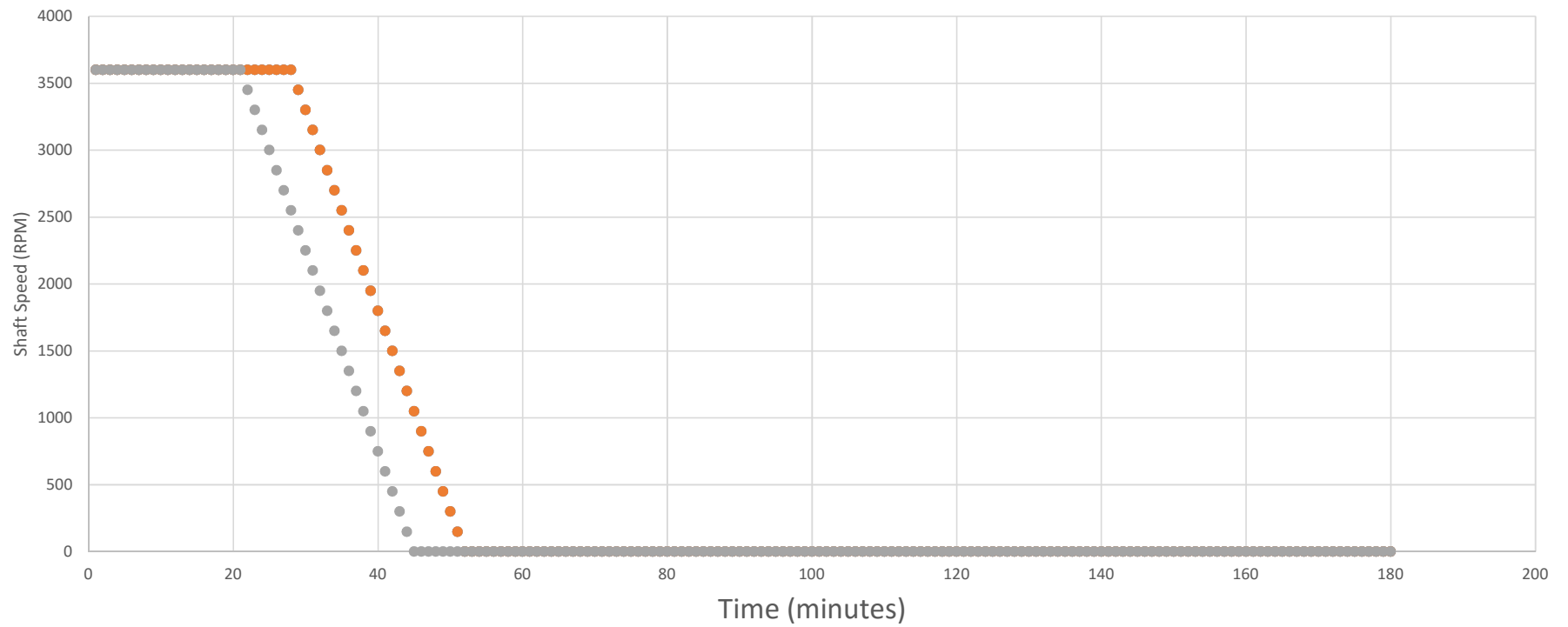
Minimum Down Time Proposed Definition

The minimum number of hours between unit shutdown and unit startup, calculated as the shortest time difference between the unit's generator breaker opening and the unit's generator breaker closure, as measured by telemetry available to PJM. **For Combined Cycles units this is the minimum number of hours between steam turbine generator breaker opening and steam turbine generator closure.**

Combined Cycle Shutdown – Unit Output



Combined Cycle Shutdown – Shaft Speed



Shutdown Phases

- ST Shutdown
 - ST Ramp
 - ST Disconnect
 - ST Spindown
 - ST on Turning Gear
- CT Shutdown
 - CT Ramp
 - CT Disconnect
 - CT Flame Shutdown
 - CT Spindown
 - CT on Turning Gear
- Turbines on Turning Gear
- Post Operation Activities
 - Tasks Differ Depending on Design

Minimum Down Time

- Shutdown
 - ST takes about 20 minutes to get on turning gear
 - CT takes about 50 minutes to get on turning gear
 - Post-operation activities take 60 minutes
 - Dispatch notice may be received during post-operation activities
- Minimum shutdown time is the sum of ST shutdown, post-operation activities, and Start Time
- If next dispatch notice is received during hot condition
 - Minimum Shutdown time should be $50 + 60 + 120 = 230$ minutes
- If next dispatch notice is received during warm condition
 - Minimum Shutdown time should be $50 + 60 + 390 = 500$ minutes

Minimum Down Time Potential Solutions

- Un-nest Parameters
 - Add additional terms to describe and demonstrate shutdown
 - ST Spindown
 - CT Disconnect
 - CT Spindown
 - Post-operation activities
 - End Minimum Down Time at the start of first CT Start Time
 - Add condition dependent Minimum Down Time
 - Hot
 - Warm
 - Cold