



Combined Cycle Start-up Cost Calculation

Thomas Hauske

Sr. Lead Engineer, Operation Analysis & Compliance

MIC Special Session - Gas Contingency Costs

June 1, 2018

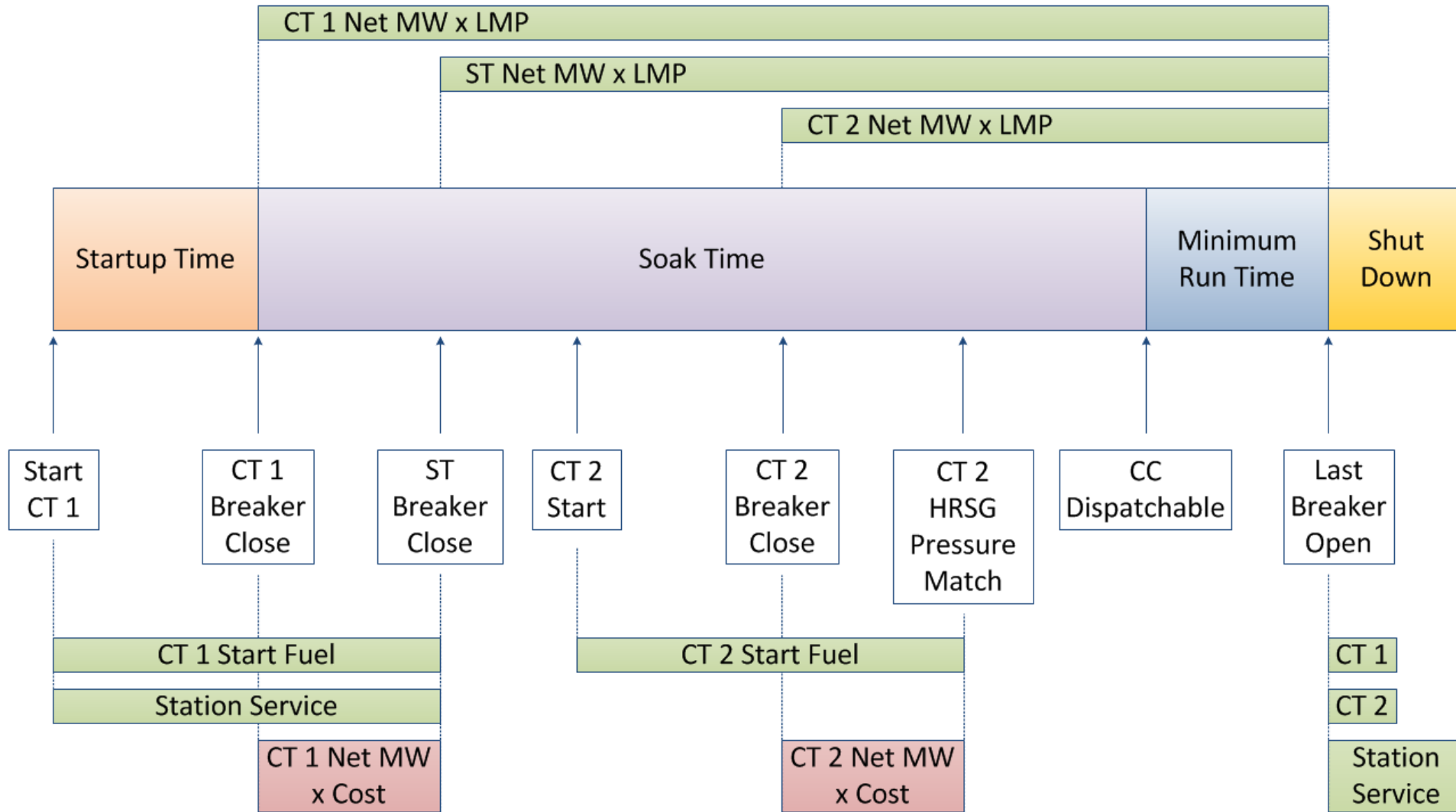
Cold/Warm/Hot Start-up Time - The time interval, measured in hours, from the beginning of the start sequence to the point after generator breaker closure which is typically indicated by telemetered or aggregated state estimator MWs greater than zero for a generating unit in its cold/warm/hot temperature state. **For a Combined Cycle unit it is the time interval from the beginning of the start sequence to the point after first combustion turbine generator breaker closure which is typically indicated by telemetered or aggregated state estimator MWs greater than zero.** Start sequence may include steps such as any valve operation, starting feed water pumps, startup of auxiliary equipment, etc.

Start-up Cost (\$/Start) =

$$\begin{aligned} & \text{Start Fuel Consumed (MMBtu/Start)} * \text{TFRC (\$/MMBtu)} * \text{Performance Factor} \\ & + (\text{Station Service (MWh)} * \text{Station Service Rate (\$/MWh)}) \\ & + \text{Start Maintenance Adder (\$/Start)} + \text{Start Incremental Labor Cost (\$/Start)} \\ & + (\text{Station Service after Breaker Open (MWh)} * \text{Station Service Rate (\$/MWh)}) \\ & - (\text{Net Generation from CT Synch to ST Synch (MWh)} * \text{Cost (\$/MWh)}) \\ & - (\text{Net Generation Shutdown (MWh)} * \text{Cost (\$/MWh)}) \end{aligned}$$

- **Start Fuel Consumed Cost** is the cost of start fuel (basic fuel cost plus fuel handling and other fuel-related costs) from first CT fire to breaker closing for the steam turbine generator, as measured during a normal start sequence, and the cost of shutdown fuel from last breaker opening to fuel valve closure. Additionally, this includes the cost of start fuel from CT first fire to the point where heat recovery steam generator (HRSG) steam pressure matches steam turbine inlet pressure, for any CT unit/HRSG combinations started after synchronization of the steam turbine generator.

- **Station Service** is included from initiation of start sequence of initial CT to breaker closing of the steam turbine generator (total station use minus normal base station use) priced at the Station Service Rate
- Add to this (+) station service after breaker opening of the last component when finished operating as a CC unit, priced at the Station Service rate. (Station service during shutdown should be that associated with the normal unit auxiliary equipment operated during shutdown in excess of base unit use. This station service is not to include maintenance use or non-normal uses.)
- Minus (-) the integration of net generation from CT synchronization to steam turbine generator synchronization or to HRSG steam output at line pressure, priced at the actual cost of the unit.
- Minus (-) the integration of net generation during the shutdown period, priced at the actual cost of the unit.



Combined Cycle Start-up Cost basically simplify to:

= CT Generation MW at (Price – Cost) during steam turbine start and HRSG pressure matching (CT in simple cycle operation)

+ CT fuel cost during CT start-up, steam turbine start-up & HRSG pressure matching (CT in simple cycle operation)

+ station service during start up of first CT and during shutdown