

The goal for this table is to provide operators with a comprehensive series of typical unit reliability improvement modifications and or upgrades and the associated typical cost ranges for each. TTS developed the evaluations using standard industry cost data and our 35+ years of experience. Costs are subject to change with the scope and evaluation of the specific unit.

Drivers	Costs	Typical Upgrade Scope	System Benefits	Potential Upgrades or Modifications	Evaluations
<ul style="list-style-type: none"> Decreasing Reliability Device System Obsolescence Increased Equipment Failures Poor starting reliability Slow starts Oil/Air Quality Issues Increased Trips Lack of operational flexibility (fuels, fast start, ISOCH mode, black start, etc.) 	<ul style="list-style-type: none"> Hydraulic/Pneumatic device replacement ranges from \$10k-\$100k For sensor upgrade/duplication, the cost ranges from \$5k to \$35k per device Switches easier and cheaper than transmitters 	<ul style="list-style-type: none"> Replace/upgrade critical switches, transmitters, and sensors: 26 QT, 63 QT, 96CD (single point of failure) Add redundant switches or transmitters to remove a single point of failure or provide backup Upgrade critical sensors: flame detectors, exhaust thermocouples, speed pickups, and Overspeed device Replace pneumatic / hydraulic device with current technology electrical device 	<ul style="list-style-type: none"> "Low hanging fruit" simple and effective upgrade Remove a single point of failure and eliminate trips Improve available information Improved reliability Improved availability Reduced maintenance 	<p>On-Base Device Upgrade and Rationalization</p>	<p>Pros: At least one of the drivers are present; the benefit is high relative to cost for implementation of redundancy and replacement of critical items.</p>
Drivers	Costs	Typical Upgrade Scope	System Benefits	Potential Upgrades or Modifications	Evaluations
<ul style="list-style-type: none"> Random Faults and trips Increased Equipment Failures Deterioration of Wiring and/or Grounds Decreasing Reliability Poor starting reliability Increased Trips 	<ul style="list-style-type: none"> On-base rewire scope for a single unit is approximately \$130k - \$150k with materials, labor and supervision Increases to \$200k + for a home run to control system, additional external conduits, extended thermocouples 	<ul style="list-style-type: none"> Replace all on-base wiring to JB-1 and JB-2 (GE units) "Homerun" to control system Run external conduit for extended exhaust thermocouples Repair / replace the internal conduit Add generator devices 	<ul style="list-style-type: none"> Eliminate grounds Eliminate canon plugs Eliminate signal leakages Improved reliability Improved availability Reduced maintenance 	<p>Rewires</p>	<p>Pros: Generally, with one or more of the drivers above, the cost is relatively low for benefits gained.</p>
Drivers	Costs	Typical Upgrade Scope	System Benefits	Potential Upgrades or Modifications	Evaluations
<ul style="list-style-type: none"> Device System Obsolescence Inadequate vendor Support Decreasing Reliability Increased Equipment Failures Oil/Air Quality Issues Increased Trips Lack of operational flexibility (fuels, fast start, ISOCH mode, black start, etc.) 	<ul style="list-style-type: none"> Valve replacement cost ranges \$200k to \$350k depending on valve selection For IGW replacement cost ranges \$200k to \$300k depending on configuration 	<ul style="list-style-type: none"> Replace Hydraulic/ pneumatic control valves with electric valves Replace Hydraulic/ pneumatic trip valves with electric valves Replace Hydraulic/ pneumatic IGW actuators with electric actuators 	<ul style="list-style-type: none"> Elimination of servos/positioners System simplification (single valve) Easier setup/calibration Improved reliability Improved availability Greatly improved functionality and flexibility 	<p>Hydraulic or Pneumatic System Removal / Fuel System Simplification</p>	<p>Cons: Without one or more of the above drivers, the cost is too high for the benefit gained.</p> <p>Pros: With one or more of the drivers, the cost is relatively low for the benefits gained.</p>

Vintage Unit Reliability Improvement Options – Cost Benefit Guidelines

Drivers	Costs	Typical Upgrade Scope	System Benefits	Potential Upgrades or Modifications	Evaluations
<ul style="list-style-type: none"> • Device System Obsolescence • Inadequate vendor Support • Decreasing Reliability • Poor starting reliability • Lack of unit information/data • Lack of unit historical data • Increased Trips • Lack of operational flexibility (fuels, fast start, ISOCH mode, black start, etc.) 	<ul style="list-style-type: none"> • Simple upgrade scope single unit, single panel, single HMI ranges \$300k - \$400k installed • Can easily double with additional scope requirements 	<ul style="list-style-type: none"> • Upgrade Governor • Upgrade entire system (governing and sequencing) • Upgrade HMI • Upgrade Historian 	<ul style="list-style-type: none"> • System simplification especially with replacement of individual protection relays • Easier setup / calibration • Improved reliability • Improved availability • Greatly improved functionality and flexibility • Improved data availability and retention • Lower maintenance costs 	<h3>Control System Upgrade (Turbine)</h3>	<p>Cons: TMR isn't worth it. Without one or more of the above drivers, the cost is too high for the benefit gained.</p> <p>Pros: With one or more of the drivers, the cost to benefit equation improves significantly.</p>
Drivers	Costs	Typical Upgrade Scope	System Benefits	Potential Upgrades or Modifications	Evaluations
<ul style="list-style-type: none"> • Device System Obsolescence • Inadequate vendor Support • Decreasing Reliability • Increased Equipment Failures • Increased Trips 	<ul style="list-style-type: none"> • Simple upgrade scope single unit, single panel ranges \$200k - \$400k • Can easily increase with additional scope requirements 	<ul style="list-style-type: none"> • Upgrade AVR • Upgrade thyristor bridge • Upgrade protection system 	<ul style="list-style-type: none"> • System simplification especially with replacement of individual protection relays • Easier setup and testing • Improved reliability • Improved availability • Greatly improved functionality and flexibility • Improved data availability and retention • Lower maintenance costs 	<h3>Generator Excitation and Protection System Upgrade</h3>	<p>Cons: Without one or more of the above drivers, the cost is too high for the benefit gained.</p> <p>Pros: With one or more drivers, the cost to benefit equation improves significantly.</p>

There are several lesscommon upgrades and modifications that would improve reliability including Partial Control System Modifications(Power Supplies), Replacing Starting System, MCC Upgrade, Synchronous Clutch Upgrade, and Oil Cooling Upgrade. If any of these feels like a solution you are interested in pursuing, please contact one of our engineers.