PRC-025-1 Generator Loadability
Realizing the Benefits of Early Adoption

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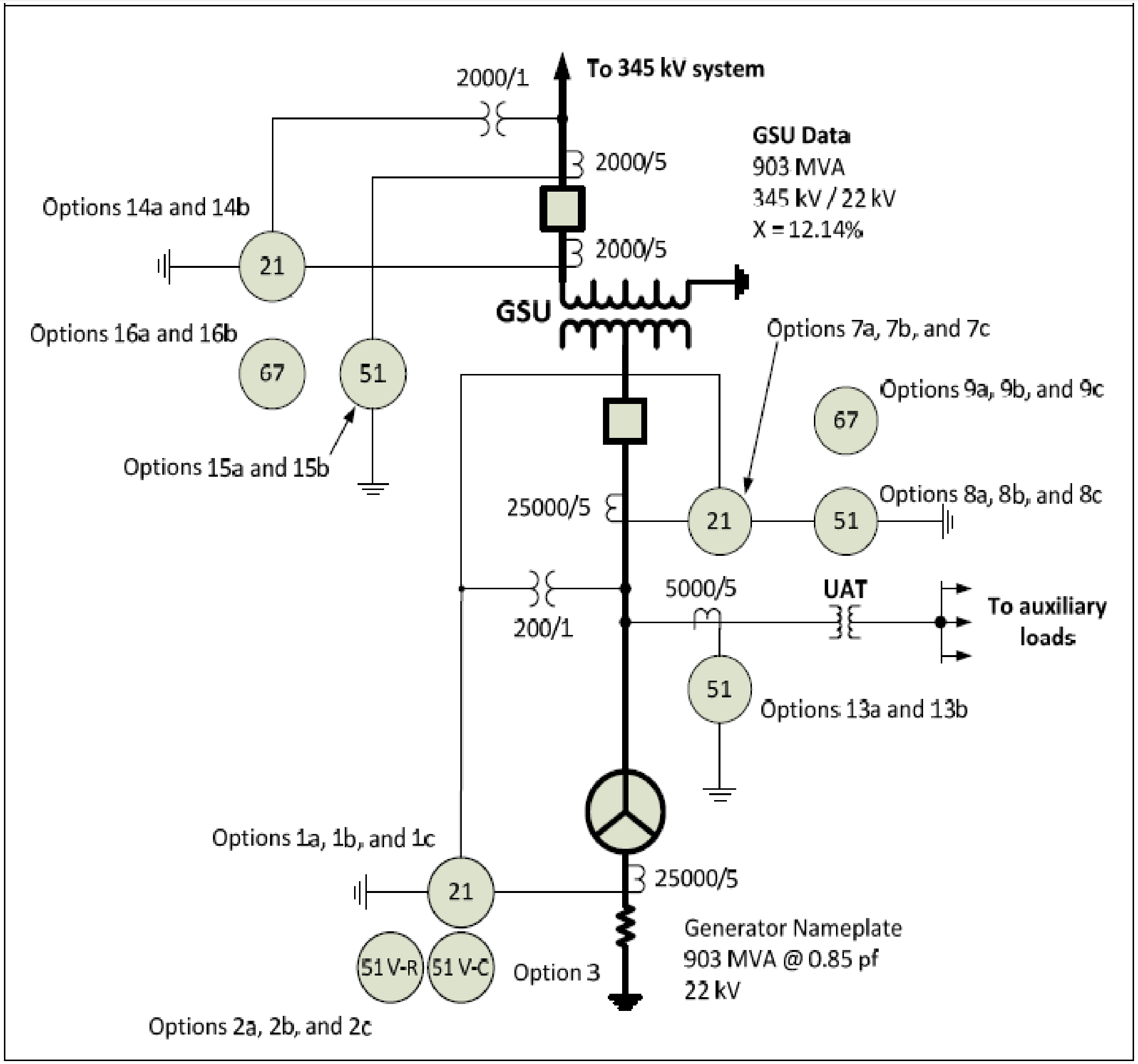
Purpose

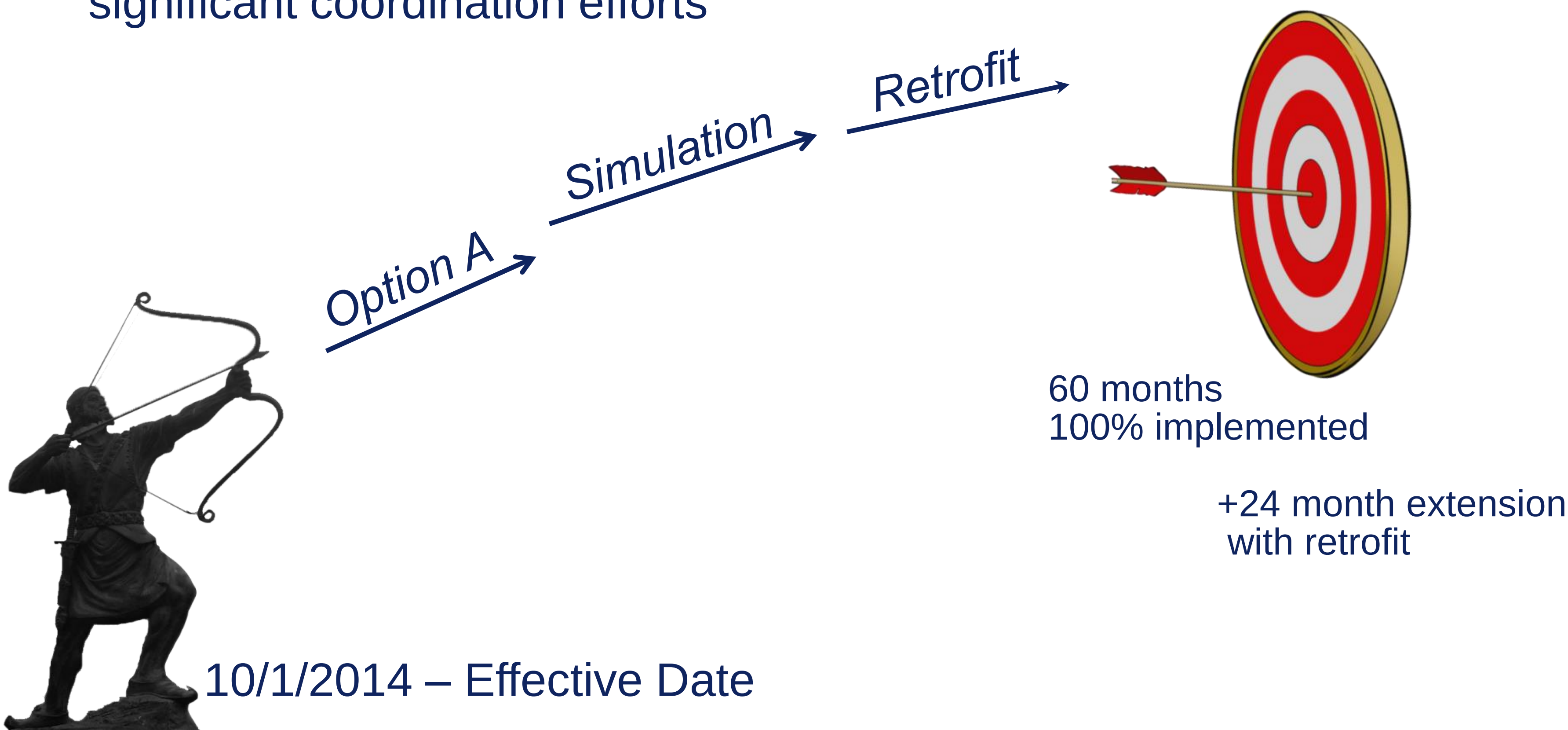
“To set load-responsive protective relays associated with generation facilities at a level to prevent unnecessary tripping of generators during a system disturbance for conditions that do not pose a risk of damage to the associated equipment.”



Timeline

Considerations:

- Implementation of settings changes requires the unit to be off line
- The outage duration to implement changes may be significant
- Replacement will require procurement time, outage scheduling, and significant coordination efforts



Process

Gather Generation Unit Data

DEMO - NERC PRC-025, Table 1 Calculation

Instructions | Nameplate Data | 21-Option 1a | 51V-Option 2a | 51C-Option 3 | 21-Option 7a | 51/67-Option 8a or 9a | AUX XFMR-Option 13a | 21-Option 14a | 51/67-Option 15a or 16a | Contact

Generator Nameplate Data

Field	Value
Generator Name:	Generation Plant #1 CTG
Maximum Unit MVA	57.985
Power Factor	0.85
Generator Rated Voltage [kV]	13.8
MW Reported to the Transmition Planing Coordinator (MW)	46.1

GSU Transformer Nameplate Data

Field	Value
GSU MVA Rating	64
GSU Reactance at MVA Rating [%]	7.43
GSU in Service TAP	2
Secondary Voltage	13.8
Primary Voltage	117.5
GSU High Side Nominal Voltage [kV]	115
Calculated Ratio	0.1174

In order to verify compliance with NERC PRC-025-1 (Generator Relay Loadability) populate ALL fields to the left prior to moving to other tabs.

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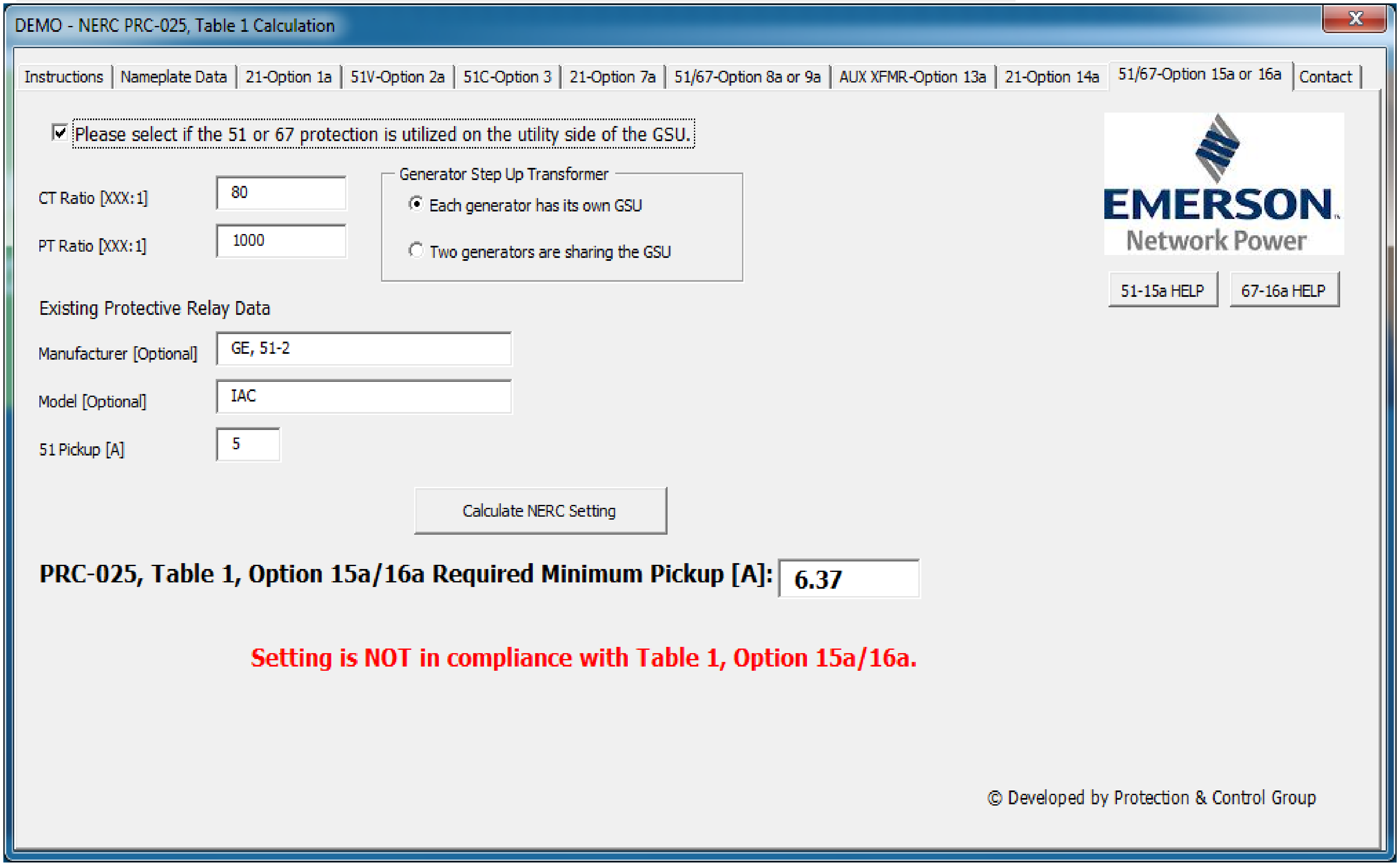
Below is the data required to populate the tool and where that data can usually be found:

- Generator's Nameplate Rating
  (generator's nameplate, 3-line drawings, 1-line drawings)
- Generator Step Up (GSU) Transformer's Nameplate Rating
  (transformer's nameplate, 3-line drawings, 1-line drawings)
- Megawatts [MW] Reported to the Transmission Planning Coordinator
  (plant documentation)
- Auxiliary Transformer's Nameplate Rating
  (transformer's nameplate, 3-line drawings, 1-line drawings)
- Current Transformer (CT) Ratio, Potential Transformer (PT) Ratio
  (3-line drawings, 1-line drawings)
- Type of Utilized Protective Relays
  (single line diagram, maintenance records, commissioning report)
- Protective Relay Settings
  (generator protection study, maintenance records, commissioning report)

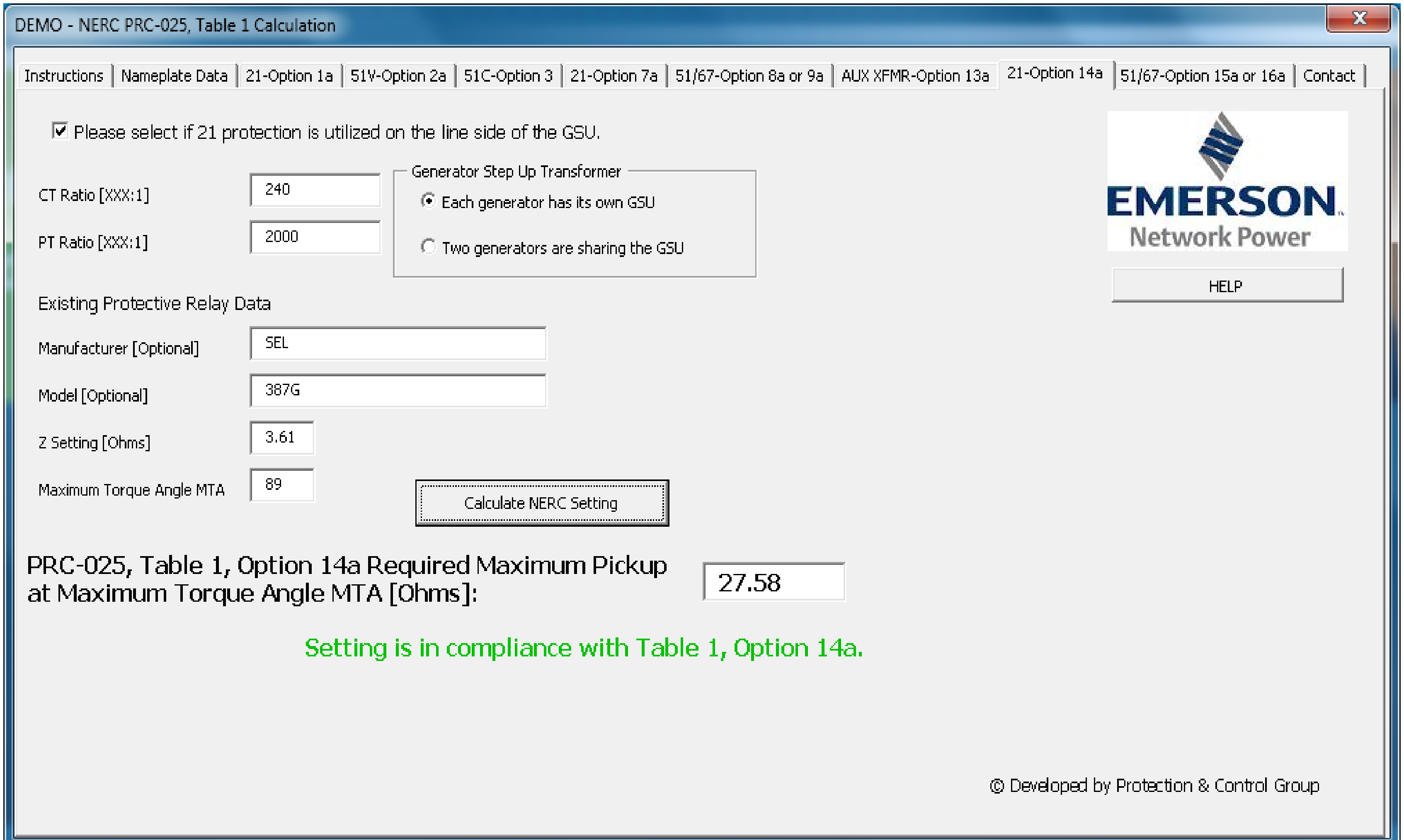
Process

Assess Load Sensitive Relays



Process

Assess Load Sensitive Relays



Considerations

	Option A *Derive Reactive Power Rating from Conservative Calculations*	**Software Simulation** *Use Field-Forcing to Determine Reactive Power Rating*
Benefits	▪ The process of assessing compliance can be automated ▪ Requires the least amount of effort to demonstrate compliance if all settings comply	▪ Majority of the settings that fail Option A pass software simulation ▪ In some cases, all settings assessed are compliant, requiring no maintenance outage or testing ▪ Fewer setting changes compared to Option A ▪ Fully modeled machines are better protected ▪ Models can be verified through testing MOD-25
Detriments	▪ High probability that generation unit will not be capable of producing calculated reactive power ▪ Increasing settings to comply sacrifices protection ▪ Changing settings requires coordination with upstream devices and may include transmission ▪ Implementing relay setting changes requires a maintenance outage and testing	▪ Complete system modeling can be challenging for older machines and sites with poor document control or lack of OEM support ▪ Modeling software is expensive ▪ Requires more engineering resources to complete assessments ▪ Requires the most amount of effort to demonstrate compliance

Case Study for Early Adoption

Example: 500 MW Combined Cycle Natural Gas Generation Unit

Gas Price= \$1.80/Million BTU   Electricity Rate = \$20/MWHr

Heat Rate 7200 BTU/KWHr

Estimated Daily Revenue = Unit rating x 24 hrs x market rate

$$= 500\text{MW} \times 24\text{hrs} \times \$20\ \frac{\text{MW}}{\text{hr}}$$

= \$240,000/day <u>or</u> \$10,000/hour

Estimated Gas Costs = (Unit rating x heat rate) x gas price

= (500 MW x 7,200 BTU/KWHr) x \$1.80/million BTU x 24 hrs

$$= \frac{(3.6\text{ Billion BTU/hr}) \times \$1.80 \times 24\text{ hrs}}{\text{Million BTU}}$$

= \$155,520/day <u>or</u> \$6,480/hour

Case Study – Forced Outage Timeline

Consideration:

The generation unit experiences a forced outage due to the operation of a load sensitive protective relay which could have been avoided by complying with PRC-025-1.

Response Time:

2 hrs - Shutdown/cool down of unit
1 hrs - Isolate and LO/TO unit for testing
2 hrs - Fault investigation – mobilize test engineers
2 hrs - Event record analysis
4 hrs - Relay testing
8 hrs - Generator and/or transformer testing
2 hrs - Start up/heat up

21 hrs -Total Elapsed Time

Case Study – Cost Impacts

Consideration:

The generation unit experiences a forced outage due to the operation of a load sensitive protective relay which could have been avoided by complying with PRC-025-1 earlier. **Penalties excluded*

Lost Revenue = Duration x revenue rate
= 21 hrs x $10,000/hr
= $210,000 lost revenue

Sunk Costs = Duration x pre-purchased fuel
= 21 hrs x $6,480/hr
= $136,080 unused fuel

Testing = Tech x hourly rate x test duration
= 3 techs x 16 hrs x $150/hr + OT/DT rates
= $10,800 testing fees

Total Impact = Lost revenue + sunk costs + testing
= $210,000 + $136,080 + $10,800
= $ 356,880 Total Cost

Case Study – Follow-up Actions – Lessons

Consideration:

The generation unit experiences a forced outage due to the operation of a load sensitive protective relay which could have been avoided by complying with PRC-025-1 earlier.

Other Hidden Costs:

- GO/GOP must file a Relay Misoperation Report
- GO performs the PRC-025-1 generator loadability study (same cost)
- Load sensitive protective relays settings require changes to comply
  - An outage will be necessary to implement
  - Re-testing of the load sensitive protective relays
  - Smaller window of time to schedule an outage to implement settings or sync with PRC-005 Protective System Maintenance Testing

Questions