Pacific Gas and Electric Company®

Major Project Business Case

DCPP Unit 2 Main Generator Stator Upgrade

Reference Name: DCPP U-2 Stator Restack

Gate 1 Authorization

Ed Halpin, Executive Sponsor
Craig Murry, Business Owner
Steve Brehm, Project Manager

June 25, 2015

1. Introduction

Project Name: DCPP Unit 2 Main Generator Stator Upgrade	**Line of Business**: Energy Supply – Diablo Canyon Power Plant
Executive Sponsor: Ed Halpin	**Business Owner**: Craig Murry
Project Start Date: 10/01/2012	**Project Manager**: Steve Brehm
EDRO: 12/08/2019	**Project Completion**: 06/30/2020
Approval Type: Gate 1 Authorization	**Project Number (WBS#)**: P.03044

A) Executive Project Committee (EPC) Action Recommended

Diablo Canyon Power Plant (DCPP) recommends that the EPC approve and recommend Utility President and Corporation CEO approval of an expenditure of $46.1M, which includes $16.6 M, or 36%, in contingency, for Gate 1 of the Unit 2 Main Generator Stator Upgrade project. Gate 1 funding will be used for project oversight, bid preparation, vendor selection, contract award and execution, vendor design, material procurement, and vendor commitment for fabrication, factory acceptance testing, and material and equipment delivery.

The total project is currently forecast to cost $151.4M, including $61.5M, or 41% in contingency.

Costs in $ millions	Gate 1 Request	Gate 2 (October 2016)	Total Project
Total Expected Case	$29.5	$60.4	$89.9
Total Contingency	$16.6	$44.9	$61.5
Total Authorized Amount (Total Worst Case)	$46.1	$105.3	$151.4

Since inception, the project has incurred $0.6M in costs for technology evaluation and selection, technical requirements, bid package preparation, vendor evaluation and selection, and project estimating and planning. The project has not yet entered into any contractual commitments.

Objective Statement: Upgrade DCPP's Unit 2 main generator stator starting in October 2012 and completing by June 2020 for a cost not to exceed $151.4M.

2. Justification

A) Overview

Problem Statement:

The Unit 2 main generator, which converts mechanical power from the main turbines into electrical energy, is critical for the safe, reliable operation of DCPP Unit 2 (U-2). The Unit 2 main generator stator[1] is reaching the end of its service life. The expected life of the stator, based on industry experience, is approximately 30 years. As of 2015, Unit 2 has been in operation for 30 years.

In addition, the Unit 2 stator has experienced, and continues to experience, the following significant operational and safety issues, which require replacement of key components:

1. Unit 2 is experiencing increasing temperatures, which indicates water blockage is occurring in the cooling water passages in the stator coils. Water blockage due to buildup of copper oxides in the stator cooling water passages has occurred on units of similar size and design throughout the industry, such as DCPP's Unit 1 and the South Texas Nuclear Unit 2.

[1] The stator is the main generator's stationary component. The stator core is made up of individually insulated magnetic steel laminations, and the stator winding is made up of insulated copper conductors.

2. The Unit 2 stator core has shorted laminations resulting in hot spots (electrical shorting between laminations due to degraded insulation causing circulating currents which generate heat at the short location). A number of attempts have been made to repair the core hot spots without success. The Unit 2 stator core also has significant core vibration. Therefore, a stator core iron replacement is required.
3. Replacement of the hydrogen cooler tube bundles is required due to age-related degradation (corrosion and wear) and the potential for lead carbonate formation. Lead carbonate is a significant health hazard.

Testing and engineering analysis indicates the Unit 2 stator is in a degraded state. Ongoing degradation is progressive and could eventually cause a catastrophic generator failure if not corrected. To date, these issues have not caused a unit shutdown.

Project Description:

This project will upgrade the Unit 2 main generator stator in-place on the turbine deck and replace the following components:

- The stator winding, end winding supports, parallel rings, main leads, bushings and current transformers, the stator core, core clamping components, instrumentation, hydrogen cooler tube bundles, blower shroud assemblies, and air gap baffles.

The project will also:

- Refurbish the lead box, modify the stator cooling water system, and replace the grout under the generator and exciter base plates.

The following components will be retained for continued use:

- The stator frame, hydrogen cooler dome, lead box, bearing brackets, hydrogen seals, generator rotor, and exciter.

This project will extend the stator's life up to 30 more years, and help ensure reliable and safe operation of DCPP.

B) Company Strategic Goal

Delighted Customers – Keeping the Lights On: The U-2 generator stator is approaching its end of life, resulting in reduced reliability. Upgrading the stator will help ensure reliable operation for up to an additional 30 years.

Public & Employee Safety: Upgrading the existing stator will mitigate an in-service failure, which would place employee safety, as well as other plant equipment, at risk.

C) Enterprise and Operational Risk and Compliance (Session D)

Nuclear Operations and Safety: Extended Shutdown Due to Equipment Failure – An extended shutdown of the Diablo Canyon Power Plant (for longer than three months or with a financial impact greater than $100.0M) due to equipment failure.

- This project will reduce the probability of a catastrophic failure of the main generator causing an extended and costly forced outage, significant employee injury from equipment failure, and negative impacts to PG&E's Institute of Nuclear Power Operations' index and regulator confidence.
- Although highly unlikely, it is possible that the project team could discover core frame conditions and issues when deconstructing the generator stator material, which are unforeseeable, that could result in outage delays. The project has captured these potential delays within the project's risk and contingency.

D) Project Benefits

Non-Financial Benefits:

- *Safety, Reliability, and Public Confidence in Utility:* Replacing equipment which is susceptible to failure will support safety, reliability, and public confidence in the Utility.
- *Industry Best Practices:* Completion of this project will align the Utility with the industry's best practices in Equipment Reliability.

Financial Benefit:

- N/A.

E) Benchmarking/Industry Experience

External: Initial project benchmarking against Arkansas Nuclear One (ANO), Duke Power, Prairie Island Nuclear, St. Lucie Nuclear, and South Texas Nuclear has been performed. Additional benchmarking is planned for 2015 - 2017. Key findings are discussed below:

Industry Experience:

- Catastrophic failure during old stator removal resulted in fatalities (ANO).
- Poor communications and coordination within the Siemens organization and with their sub-vendors impacted the schedule, which resulted in outage delays.
- Insufficient time in the project development phase resulted in cost and schedule impacts (Duke Power).
- Lack of appropriate foreign material exclusion controls created start-up delays and caused equipment damage (Duke Power).
- Project schedule development was not a collaborative process, which caused a lack of ownership and accountability (DCPP & Duke Power).
- Lack of generator mitigation strategies resulted in a reactor trip and an extended forced outage (South Texas Nuclear).

Internal: The DCPP Unit 1 main generator stator was rewound in 2004 due to blockage of the cooling water passages in the stator coils. The scope of the Unit 1 project is not representative or comparable to the Unit 2 scope primarily because Unit 2 will require a core replacement. The Unit 1 project only involved a rewind of the existing stator ($18.0M) (no degraded conditions were identified in the core material of Unit 1). The Unit 2 project will remove, purchase, fabricate, and replace the stator core, windings, and other major stator components, such as the hydrogen coolers and blowers ($89.9M). Lessons Learned from the Unit 1 rewind in terms of cost and scheduling will be reviewed as part of the Unit 2 project development.

3. Implementation

A) Current Status

Since inception, the project has incurred $0.6M in costs for technology evaluation and selection, technical requirements, bid package preparation, vendor evaluation and selection, estimating, and project planning. The project has not yet entered into any contractual commitments.

The team expects to enter into $51.9M of contractual commitments by the end of August 2015 to award a contract to a successful bidder (Siemens). A project off-ramp, scheduled for September 2016, is being negotiated into the contract to allow the project team to terminate further cost and project execution in the event that a DCPP licensing extension is not pursued. The hard contractual commitment of $25.1M before the project's off-ramp will cover vendor design and engineering, and fabrication and delivery of major components; all of which will be required to mitigate the risk of an equipment failure regardless of the plant's license extension decision. If licensing extension is not pursued, then DCPP engineering will develop a "bridging strategy" for monitoring equipment health for the remaining service life of the main generator.

The contractor will assume responsibility for labor, material, and equipment. More specifically, the contractor will provide the design, procurement, fabrication of all materials, labor, tools, implementation supervision, project management, planning, scheduling, reporting, preparation of DCPP design change packages, and licensing documents. DCPP has begun establishing the appropriate oversight organization to manage this contract.

PG&E will provide project oversight of fabrication, engineering design reviews, project subject matter experts, station coordination, and project implementation support.

Upon completion of vendor design in September 2016, the project team expects the cost estimate to be an AACE Class 3 or better. Therefore, the team is planning to seek full project authorization from the Board in the fourth quarter of 2016.

The project will be integrated into the outage schedule in accordance with the pre-outage milestone plan in two phases:

- **Phase 1** - spring of 2018 (2R20): Remove the exciter from its base to restore the bed plate grout, open the main generator and perform critical core component measurements to verify and identify interferences, and perform robotic testing to extend the core to the fall 2019 outage per Nuclear Electric Insurance Limited requirements.
- **Phase 2** - fall of 2019 (2R21): Remove and replace core iron and windings, upgrade cooler system, and build the stator core on the turbine deck.

On every DCPP project, including this one, all vendor employees will receive the security clearance required to work at a nuclear plant. Vendor employees will be trained and will pass various levels of General Employment Training. All material, equipment, and tools will be screened and approved to move through the security boundary. Temporary power needs will be identified and provided on location.

Thus far, the project has developed and issued an RFP, and evaluated and selected the contractor. The next steps in Gate 1 are to negotiate and execute contracts, provide oversight for vendor design, and procure materials. In Gate 2, the project will prepare for, and implement, the project by completing schedule development, design change package preparation, fabrication of engineered components, factory testing and delivery of components, work package development, project mobilization and installation, demobilization, and project closeout.

C) Detailed Scope

Major Scope Items	Start Date	Percent Complete	End Date
Gate 1: October 2012 – September 2016			
• Develop and issue RFP, evaluate and select bidder, negotiate and execute contracts	10/2012	85%	07/2015
• Project oversight for contract development and vendor design	06/2014	4%	09/2016
• Vendor engineering and design	08/2015	0%	09/2016
• Vendor material procurement	08/2015	0%	09/2016
Gate 2: October 2016 – June 2020			
• Vendor fabrication, testing, and shipping of stator coils and core sections	10/2016	0%	07/2017
• Project oversight & support: Outage preparation, outage schedule development, project implementation, design change package, and work package preparation	10/2016	0%	02/2018
• Outage preparation and execution for spring 2018 (2R20)	07/2017	0%	04/2018
• Outage preparation and execution for fall 2019 (2R21)	07/2017	0%	12/2019
• Project closeout (package closure, vendor demobilization and serviceability testing, and contract closure)	01/2020	0%	06/2020

C) Land and Environmental Considerations

There are no expected changes in the types, characteristics, or quantities of any effluents (liquid, gas, solid) discharged to the environment associated with the proposed project. Hazardous waste will be disposed of in accordance with DCPP procedures, and copper and steel from the old winding and core will be recycled. Hazardous materials to be used during implementation will be approved for use at DCPP in accordance with DCPP procedures.

Because the stator will be re-stacked within the turbine building, such that a large pre-assembled stator unit does not need to be barged in nor a new warehouse be constructed, no discretionary permits are required.

No easements, land acquisition, or right of ways associated with this project are expected to be required. Some type of encroachment permit for crossing the existing bridge over San Luis Creek could be required from the County of San Luis Obispo depending on the weight and physical dimensions of the equipment trucked to the DCPP site. All materials will be shipped within Department of Transportation weight limits. No heavy hauler is required. The supplier will be responsible for obtaining any permits for shipment of materials (wide load, etc.). Materials will be packaged for outdoor storage, or will be stored in existing warehouses or temporary seatrains. Nothing will be shipped by barge.

D) Project Dependencies

N/A.

4. Financials

A) Cost Forecast

Annual Cost Forecast in millions $	Prior Years	2015	2016	2017	2018	2019	2020	Total
Capital (Expected Case)								
Labor	$ 0.1	$ 0.2	$ 1.0	$ 3.1	$ 3.2	$ 5.5	$ 0.6	$ 13.7
Material	$ -	$ 0.1	$ 0.0	$ 0.0	$ 0.1	$ 0.1	$ -	$ 0.3
Contract	$ 0.1	$ 4.2	$ 14.7	$ 10.3	$ 5.5	$ 12.8	$ 11.6	$ 59.2
Other	$ 0.3	$ 0.1	$ 0.3	$ 0.6	$ 0.4	$ 1.2	$ 2.9	$ 5.6
AFUDC	$ 0.0	$ 0.1	$ 0.9	$ 2.5	$ 3.7	$ 3.7	$ -	$ 11.0
Total Capital	**$ 0.5**	**$ 4.7**	**$ 16.9**	**$ 16.5**	**$ 12.9**	**$ 23.3**	**$ 15.1**	**$ 89.9**
Total Project (Expected)	**$ 0.5**	**$ 4.7**	**$ 16.9**	**$ 16.5**	**$ 12.9**	**$ 23.3**	**$ 15.1**	**$ 89.9**
Project Cost (Best Case)								
Capital	$ 0.5	$ 4.7	$ 16.1	$ 13.8	$ 12.5	$ 21.6	$ 13.2	$ 82.4
Total Project (Best)	**$ 0.5**	**$ 4.7**	**$ 16.1**	**$ 13.8**	**$ 12.5**	**$ 21.6**	**$ 13.2**	**$ 82.4**
Project Cost (Worst Case)								
Capital	$ 0.5	$ 7.1	$ 26.1	$ 23.6	$ 24.3	$ 40.9	$ 28.8	$ 151.4
Total Project (Worst)	**$ 0.5**	**$ 7.1**	**$ 26.1**	**$ 23.6**	**$ 24.3**	**$ 40.9**	**$ 28.8**	**$ 151.4**

B) Cost Assumptions

Best Case Scenario: $82.4M (10% Confidence Level)
The best case scenario assumes all risks outlined in the Risk Allowance Table do not materialize.

Gate 1: $28.7M

- **Develop and Issue RFP, Evaluate and Select Bidder, Negotiate and Execute Contract: $0.7M**
  - 4,000 labor hours at an average rate of $175 /hr.
- **PG&E Project Oversight: $1.2M**
  - Project oversight team consists of project managers, project engineers, field engineers, work planners, project controls and subject matter experts (starting in August 2015 and completing in October 2016)
    - 7,100 labor hours at an average rate of $175 /hr.
      - 3 to 10 men for 14 months
- **PG&E Preliminary Engineering: $0.6M**
  - Includes PG&E engineers and engineer of choice performing preliminary analysis and calculations to support 2R20 and 2R21 design change packages
    - 3,400 labor hours at an average rate of $165 /hr.

- 4 engineers for 6 months

- **Vendor Engineering and Design: $11.3M**
  - Based on vendor proposal
- **Vendor Commitment for Fabricate, Test and Ship Stator Coils and Core Sections: $13.8M**
  - Based on vendor proposal
- **Capital A&G: $0.1M**
  - Based on Capital A&G rate of 14.3% of PG&E labor
- **Allowance for Funds Used During Construction (AFUDC): $1.0M**
  - Based on AFUDC rate of 8.6%

Gate 2: $53.7M

- **PG&E Project Oversight and Support: $6.4M**
  - Project oversight team consists of project managers, project engineers, field engineers, work planners, project controls and subject matter experts (starting in August 2017 and completing at the end of the project)
    - 36,570 labor hours at an average rate of $175 /hr.
      - 5 to 8 men for 3.5 years (+ outage overtime)
- **Fabricate, Test and Ship Stator Coils and Core Sections for 7/2017: $0**
  - $0: Vendor fabricate and deliver - Cost included in Gate 1 above (contractual commitment); remainder of work executed in Gate 2
- **Outage Preparation and Execution for Spring 2018 (2R20): $5.7M**
  - $2.9M: Vendor installation – exciter grouting and internals inspection / field measurement
    - Based on vendor proposal
  - $2.8M: PG&E design change package development and outage support:
    - Includes PG&E / engineer of choice engineering design change packages, quality assurance personnel, non-destructive examination, and supplemental project managers
    - 17,000 labor hours at an average rate of $165/hr.
      - 6 engineers for 12 months + 8 men for 2 shifts for 20 days
- **Outage Preparation and Execution for Fall 2019 (2R21): $28.1M**
  - $21.2M: Vendor installation – Rebuild Stator In-Place, etc.
    - Based on vendor proposal
      - 6 engineers for 12 months + 8 men for 2 shifts for 20 days
  - $5.4M: PG&E design change package development and outage support
    - Includes PG&E / engineer of choice engineering design change packages, quality assurance personnel, non-destructive examination, and supplemental project managers
    - 32,700 labor hours at an average rate of $165/hr.
      - 6 Engineers for 18 months + 8 men for 2 shifts for 70 days
  - $1.5M: Electrical installations
    - Based on 15,000 craft labor hours at an average rate of $100/hr.
      - 12 men for 2 shifts for 60 days
- **Sales Tax and Material Burden on Materials: $2.0M**
  - $1.7M: Based on 8.75% of material portion of vendor contract ($19.5M)
  - $0.3M: Material burden on all warehouse consumable materials
- **Project Close-out: $0.4M**
  - 2,285 labor hours at an average rate of $175/hr.
- **Capital A&G: $1.1M**
  - Based on Cap A&G rate of 14.3% of PG&E labor
- **Allowance for Funds Used During Construction (AFUDC): $10.0M**
  - Based on AFUDC Rate of 8.6%

Worst Case Scenario: $151.4M (90% Confidence Level)
The Worst Case Scenario assumes the occurrence of all risks in the Risk Allowance Tables below. The cost estimate is the Best Case Scenario of $82.4M plus the total risk allocation of $69.0M shown in the risk allowance table.

The project cost estimate is a Class 4 on the AACE estimate classification system. The accuracy band for Class 4 estimates ranges from –30% to 50%. The project Class 4 rating is based on the firm price quoted by the vendor, a bottoms-up cost approach using benchmarking from similar projects, and cost estimates from subject matter experts.

Gate 1 Authorization: $46.1M (AACE Class 4 Cost Estimate)
Best Case $28.7M + Identified Risks $2.2M + AACE Cost Estimate Uncertainty $15.2M = Gate 1 Worst Case $46.1M

Gate 2 Authorization: $105.3M (AACE Class 4 Cost Estimate)
Best Case $53.7M + Identified Risks $16.5M + AACE Cost Estimate Uncertainty $35.1M = Gate 2 Worst Case $105.3M

#	Risk Allowance Table (Probability of Occurrence / Difficulty of Timely Detection / Impact to Scope, Schedule)	Impact on Cost
	Gate 1	
1	**Issues Identified During Contract Negotiations**: During the contract negotiation and initial implementation phases, the project team could identify gaps not currently represented in the vendor's proposal that could impact the overall project scope, schedule, and cost. For example, the project may discover that the vendor's paints or component materials do not meet PG&E standards. This risk is expected to be reduced upon contract agreement (by the end of August 2015) with Siemens. **Mitigation**: Perform additional benchmarking to identify potential scope issues. Thoroughly evaluate vendor proposal prior to contract award. **Contingency**: The project team will implement the changes required by each issue. Project managers, engineers, and vendor will work toward an appropriate solution. *Cost Impact Assumptions:* • Assumes discovery of 3 gaps at $500K per issue: o $0.3M: 1,800 labor hours at an average rate of $165/hr. per issue o $0.2M in material costs per issue **(L, M, M)**	$1.5M
2	**Additional Design Requirements:** Design assumptions could be less conservative than actual conditions. Siemens could identify more extensive scope requirements during design of the stator water cooling system. **Mitigation:** Develop and implement a plan to perform a detailed technical review. Perform walk downs and verify dimensions during the outage prior (2R20 in the spring of 2018) to this project's implementation outage to vet the design before contract execution. **Contingency:** Assumes contract execution is impacted by 3 months and vendor design costs increase. The project will provide additional oversight to the vendor's engineering group to ensure impacts are minimized. *Cost Impact Assumptions:*	$0.5M

#	Risk Allowance Table (Probability of Occurrence / Difficulty of Timely Detection / Impact to Scope, Schedule)	Impact on Cost
	• Assumes 3 months of vendor engineering @ $150K / month • Assumes 300 hours of PG&E engineering oversight at $165/hr. **(M, M, M)**	
3	**Material Cost Escalation:** The cost of raw materials required to fabricate the stator sections and coils could come in higher than anticipated at the time of contract award. **Mitigation:** Develop and implement a detailed negotiations strategy in which the vendor will assume material cost escalation risk. **Contingency:** Procurement will work with vendor to process appropriate change orders. *Cost Impact Assumptions:* • Assumes an 8% increase on a $2.4M material order for stator components. **(M, M, L)**	$0.2M
	Subtotal (Identified Risks) Gate 1	**$2.2M**
	AACE Cost Estimate Uncertainty (Unknown Unknowns): The Gate 1 cost estimate is a Class 4 estimate based on the AACE cost estimate classification system. Class 4 carries an accuracy band of -30% to +50%. Risk allowance to cover cost estimate unknowns is applied at 50%, the upper range factor, multiplied by: Best Case ($28.7M) plus currently identified risks ($2.2M) minus Costs Incurred to Date ($0.6M). Calculation: 50% x [$28.7M + $2.2M - $0.6] = $15.2M	**$15.2M**
	Total Risk Allowance Gate 1	**$17.4M**
	Gate 2	
4	**Damage to an Internal Component Discovered During 2R20 Inspections:** An internal component could be discovered to be damaged during the 2R20 inspection. The component could need to be replaced, which would require expedited fabrication and delivery of a replacement part by Siemens. **Mitigation:** A thorough internal inspection will be performed prior to the installation outage, with focus on the condition of critical internal components. **Contingency:** Expedite a replacement via the vendor. *Cost Impact Assumptions:* • $5.4M: Assumes escalated cost of expedited fabrication and delivery (at 2 times original purchase): 2 x $2.7M = $5.4M **(M, M, H)**	$5.4M
5	**Contractor Labor Cost Escalation:** The contractor may seek to collect escalation on its milestone payments because of increases in labor cost after 2016, per PG&E's contract clause that allows for labor escalation. **Mitigation:** Develop and implement a detailed negotiations strategy in which the vendor will assume the cost of escalating labor rates. **Contingency:** Procurement will work with the vendor to process appropriate change orders. *Cost Impact Assumptions:* • $4.7M: Assumes annual compounding 3% interest on milestone payments over 4 years	$4.7M

#	Risk Allowance Table (Probability of Occurrence / Difficulty of Timely Detection / Impact to Scope, Schedule)	Impact on Cost
	(2017 – 2020) **(M, M, L)**	
6	**Schedule Delays Extend the Outage Duration**: Implementation of the project could progress more slowly than anticipated, necessitating extension of the DCPP Unit 2 outage duration by 5 days. This could result from difficulties removing components or the need to repair stator frame welds. **Mitigation:** The project will provide implementation oversight and maintain stringent adherence to the project plan. PG&E subject matter experts will be part of the oversight team to provide timely support as required. **Contingency:** Contingency funds will be released to cover extended project activities, such as project oversight, and cover labor cost to DCPP organizations that are required to continue the Unit 2 outage. *Cost Impact Assumptions:* • Assumes a 5 day extension of the outage and impact to DCPP organizations at a cost of $0.5M/day **(L, M, H)**	$2.5M
7	**Testing During Commissioning Does Not Confirm Expected Result**: After completion of the implementation phase of the project, the main generator stator could fail the return to service test, requiring re-work inside the generator. **Mitigation:** The oversight team will provide oversight through all phases of the project and maintain stringent adherence to the project plan. PG&E subject matter experts will be engaged in the Maintenance Verification Testing process to ensure timely reporting of all discovered items. **Contingency:** Verify correct component installation, perform generator tests through return to service, and complete connection to the grid. *Cost Impact Assumptions:* • $2.0M: Assumes a 10 day extension of the outage at a cost of $0.2M/day. The plant remains in hot shutdown, the majority of temporary outage personnel are released, and impact to DCPP and other projects is minimal. **(L, M, H)**	$2.0M
8	**Damage to Critical Fabricated Component:** A critical component could be damaged during handling, requiring expedited fabrication and delivery of a replacement part by Siemens. **Mitigation:** A logistics coordinator will oversee all material handling in order to minimize handling and reduce the risk of any issues with the fabrication, once delivered to the site. **Contingency:** Expedite a replacement via the vendor. *Cost Impact Assumptions:* • $1.9M: Assumes escalated cost of expedited fabrication and delivery (at 3 times original purchase) and 10% of project components ($6.3M) are replaced: 3 x $0.63M = $1.9M **(L, M, H)**	$1.9M

#	Risk Allowance Table (Probability of Occurrence / Difficulty of Timely Detection / Impact to Scope, Schedule)	Impact on Cost
	Subtotal (Identified Risks) Gate 2	**$16.5M**
	AACE Cost Estimate Uncertainty (Unknown Unknowns): The Gate 2 cost estimate is a Class 4 estimate based on the AACE cost estimate classification system. Class 4 carries an accuracy band of -30% to +50%. Risk allowance to cover cost estimate unknowns is applied at 50%, the upper range factor, multiplied by: Best Case ($53.7M) plus currently identified risks ($16.5M) minus Costs Incurred to Date ($0.0M). Calculation: 50% x [$53.7M + $16.5M] = $35.1M	**$35.1M**
	Total Risk Allowance Gate 2	**$51.6M**
	Total Project Risk Allowance	**$69.0M**

Expected Case Scenario: $89.9M (50% Confidence Level)
The Expected Case cost estimate is the Best Case estimate ($82.4M) plus the probability-weighted sum of the identified risks in the Risk Allowance Table ($7.5M). Likelihood factors of 0.25, 0.5, and 1.0 were used for low, medium, and high probabilities of occurrence, respectively.

- **Issues Identified During Contract Negotiations: (+$0.4M of $1.5M) –** The project oversight team and subject matter experts are reviewing all of the details of the vendor's proposal prior to award of contract; therefore, cost underestimation due to vendor's misinterpretation of scope is estimated to have low probability of occurrence.
- **Additional Design Requirements: (+$0.3M of $0.5M) –** This will be the first of a kind project for DCPP. Design issues will not be apparent until the engineering phase; therefore, the additional design requirements risk is estimated to have medium probability of occurrence.
- **Material Cost Escalation: (+$0.1M of $0.2M) –** The primary material involved in the stator core fabrication is copper, which experiences price fluctuations on a daily basis. Material cost increases between the time of bid and award of the vendor's proposal is estimated to have a medium probability of occurrence.
- **Damage to an Internal Component Discovered During 2R20 Inspections: (+$2.7M of $5.4M) –** The internal component could be discovered to be damaged during the 2R20 inspection and could require replacement. The risk of discovering a damaged component is estimated to have medium probability of occurrence.
- **Contractor Labor Cost Escalation: (+$2.4M of $4.7M)** – PG&E's request for proposal allows for escalation on the contract price beyond January 2016. The project anticipates escalation to be negotiated into the firm fixed price of the contract before award. The contract cost escalation risk is estimated to have a medium probability of occurrence.
- **Schedule Delays Extend the Outage Duration**: **(+$0.6M of $2.5M) –** Significant planning, oversight, and project controls are included in the project plan to ensure a successful execution of all phases of the project; therefore, the risk of schedule delays that extend the outage duration is estimated to have a low probability of occurrence.
- **Testing During Commissioning Does Not Confirm Expected Result**: **(+$0.5M of $2.0M) –** Incremental inspections, subject matter expert support, project oversight, and maintenance verification tests are planned for the testing phase; therefore, the risk of unanticipated test results is estimated to have a low probability of occurrence.
- **Damage to Critical Fabricated Component: (+$0.5M of $1.9M) –** The critical fabricated components will be handled several times after delivery and during installation. These components will be crated and protected during delivery and handling; therefore, the risk of damaging a critical fabricated component is estimated to have a low probability of occurrence.

C) Funding Status

This project is fully funded in the 2015 DCPP capital budget with $4.7M. DCPP has committed to funding future years' project work within the LOB's approved budget.

D) Regulatory Treatment and Cost Recovery

This project was specifically called out as a line item in the 2017 GRC for $77.0M. The remaining $12.9M in Expected Case project costs, which is forecast in 2020, will be filed in the 2020 GRC. The 2017 GRC filing is in progress, and the opportunity to make adjustments has passed.

E) Accounting Implications

The following is the preliminary conclusion of Accounting Advice based on the facts and circumstances of the Unit 2 Main Generator Stator Upgrade Project as presented. Any change in facts and circumstances may result in a change to the accounting conclusion.

The proposed accounting and classification of project costs as capital expenditures is in accordance with accounting guidance and PG&E policy. All project costs relate to the installation of approved units of property to replace the stator core, windings, and other major stator components, such as the hydrogen coolers and blowers.

F) Tax Implications

It is not anticipated that the project will have any materially adverse income tax implications.

5. Alternatives Analysis

A) Recommended Alternative

A technical team comprised of industry experts and knowledgeable plant staff performed a structured in-depth analysis (Kepner-Tregoe Analysis) of acceptable options to restore the generator to a condition where it can provide reliable, event-free operation for up to an additional 30 years. The team evaluated nine options; five of the nine were eliminated, including status quo. The remaining alternatives were ranked according to 28 different criteria, which were weighted based on importance. The selected alternative was the recommended proposal.

The proposed project implementation alternative was selected because it resolves all of the issues described in the problem statement at the lowest cost, it doesn't require permits for transportation of components to the site, it has the lowest safety risk as it doesn't require movement of large heavy loads over nuclear safety related equipment or require extensive seismic analysis, and long-lead time materials can be purchased in time for the proposed spring 2018 2R20 implementation.

B) Alternatives Considered

Proposal NPV: -$73.3M	**Replace the stator core with new technology, rewind in-place, and use existing rotor:** Implementation will resolve all the problems described in the problem statement for a comparably low cost. This project doesn't require permits for transportation, there is low nuclear safety risk, and lead time for material delivery is short. However, a long outage duration is required for implementation.
Status Quo NPV: N/A	**Status quo is equivalent to run-to-failure**: An in-service failure will result in an extended forced shutdown and expedited repairs. At a minimum, an in-service failure would result in smoke and debris being blown throughout the generator, necessitating extensive cleaning in addition to repairs. There would be potential for hydrogen leakage and/or fire, placing personnel and other equipment at-risk. Status quo is not considered to be a viable alternative.
Alternative 1 NPV: -$136.7M	**Rewind using existing technology, perform a major repair the stator core, install a new winding in-place, and use existing rotor:** This alternative resolves all the problems described in the problem statement, except the core issues. The alternative doesn't require permits for transportation, there is low nuclear safety risk, and lead time for materials is short. However, a long outage is required to implement the project. The partial core replacement leaves vulnerabilities in the section of the core that is re-used, which maintains the risk of catastrophic failure.

Alternative 2 NPV: -$146.7M	**Purchase and replace the entire stator assembly with a new like-for-like stator using new technology and existing rotor:** This alternative resolves all of the problems described in the problem statement. The stator can be replaced in a short (~30 day) outage with minimal modification required to plant interfaces. However, the cost is significantly higher, and the alternative requires permits for transportation (barge landing) and/or temporary buildings, has a high nuclear safety risk, and entails movement of equipment required for safe shutdown of the reactor.

6. Project Governance

A) Approval History

Approval Type	Approval Date	Authorized Amount	Total Project Forecast Cost	Description
Advance Reauthorization	02/2013	$850K	$95.0M	Develop a purchase specification and RFQ by engineering.
Advance Reauthorization	02/2012	$50K	$62.0M	Scoping and logistics study to evaluate U-2 main generator stator condition and performance.
Advance Authorization	09/2010	$25K	$30.5M	Analyze the stator windings' condition and assist in recommending the timing for performing the rewind.

B) Gating Strategy

The 2 gate strategy is being pursued to facilitate accurate cost estimation and effective project implementation. Gate 1 will allow for execution of the contract with the primary vendor. This will fund mobilization, design and fabrication of critical long-lead items, project oversight, and preliminary engineering and planning for the early phase of implementation. In Gate 1, the AACE Class 4 will be reduced to an AACE Class 3 on Sept 1, 2016 when the vendor engineering is complete. The project will present to the PG&E Board at that time.

The project will return for a Gate 2 authorization in October 2016 when vendor design is complete and the implementation scope for the 2R20 (03/2018) and 2R21 (10/2019) refueling outages is more clearly defined. The project plans to seek full authorization from the Board in the fourth quarter of 2016 after receiving Gate 2 approval from the EPC.

C) Project Management Applied Lessons Learned and Best Practices

DCPP Unit 1 & 2 Reactor Vessel Head Replacement: The project experienced numerous commercial challenges and unplanned expenditures due to discrepancies in interpretation of the specifications/contract. The project had an over-reliance on vendor engineering expertise when developing the implementation section of the specifications. As a result, the vendor's product required detailed reviews and multiple revisions. Significant energy, resources, and funds are required for proper vendor oversight to ensure the required deliverables meet the desired quality.

Given the lessons learned from the DCPP Unit 1 & 2 Reactor Vessel Head Replacement project, this project will develop a thorough vendor oversight plan in the areas of engineering, manufacturing, project plan development, and project execution.

PG&E Rock Creek and Helms – The relevant lessons learned from these projects will be reviewed and evaluated for incorporation into the project planning and contracting strategy. Contract negotiations on the U2 Main Generator Stator project are being conducted by a key individual who was involved in these projects

D) Success Criteria

- Safely implement the project without any recordable personnel injuries or safety violations.
- Successful implementation of the project with no operational issues.
- Complete the project within the approved budget and schedule.

E) Company Metrics

- **Safety**: By adhering to PG&E's safety guidelines, and in keeping with the industry standard including lessons learned, management does not anticipate any impact on the company's safety record.
- **Outage Duration:** This project is the driver of the fall 2019 (2R21) outage. Project implementation is aligned with the 2R21[2] outage schedule. Any schedule delay will be monitored for impact to outage duration and cost.

F) Project Execution Metrics

- **Safety:** Recordable Incidents and Motor Vehicle Incident will be tracked.
- **Environment:** Notices of compliance deviations and Notice of Violations will be tracked.
- **Earned Value:** This project will begin reporting Earned Value (CPI & SPI metrics) in August 2015.

G) Ongoing Monitoring and Reporting

Project Manager will provide monthly reports on the status of project execution and spend. Should an issue arise that could impact the project schedule, scope, or cost (including potential use of contingency), the Project Manager will notify the Executive Sponsor, any other governing bodies specific to the line of business, as well as Project Governance, who will coordinate communication to the Executive Project Committee, as appropriate.

Appendix

I. Flexibility Matrix

	Least Flexible	Moderately Flexible	Most Flexible	Comments
Schedule	X			Project must be executed no later than the spring of 2018 and the fall of 2019 (2R20 and 2R21) refueling outages due to the deteriorated state of the main generator stator in DCPP Unit 2 and the risk of a catastrophic failure.
Scope		X		The scope is moderately flexible because it has not been fully defined yet.
Resources			X	Resources are the most flexible; project personnel can be selected from in-house personnel, consultants, or contractor firms.

[2] 2R21 Refueling Outage is scheduled to start on 9/29/2019 and complete on 12/16/2019

II. Cost Estimating Confidence Analysis

Cost Estimate Confidence Score		2.5
Category	**Score Criteria**	**Rank (1-5)**
Uniqueness of Work	5 - Team has extensive experience in this type of project 3 - PG&E has moderate experience in this type of project 1 - PG&E has little to no experience for this type of project	2
Cost Estimate Rigor	5 - Detailed bottoms up estimate with high certainty on cost elements 3 - Detailed bottoms up cost estimate complete but uncertainty on cost elements 1 - Use of "rule of thumb" or benchmark estimates	3
Risk Mitigation	5 - High confidence that risks are identified and mitigation plans are in place 3 - Some lower impact risks may not have full mitigation 1 - Risks and mitigation not identified or included in estimate	2
Project Scope	5 - Scope is well defined with no expectation of uncertainty or scope change 3 - Scope defined but expectations of minor revision over life of the project 1 - Scope is not well defined	3

III. Resources and Stakeholders

A) Internal Resources

Resource Name	Skills Needed	Department	Timeframe Needed	% of FTE Needed	Commitment Obtained (Y/N)
Craig Murry	Project Execution	Work Management	Thru 06/2020	25	Y
Steve Brehm	Project Oversight	Outage Management	Thru 06/2020	50	Y
Debbie Ferraro	Purchasing	Procurement	Thru 07/2015	25	Y
Larry Atwood	Contract	Sourcing	Thru 07/2015	25	Y
Robert Fiore	System Engineer	Engineering	Thru 06/2020	10	Y
Kent Rogers	Project Manager	Maintenance	Thru 06/2020	50	Y
Mike Brass	Project Manager	Outage Management	Thru 06/2020	50	Y
Shawn Farley	Project Estimating	Project Management Office	Thru 06/2020	50	Y
Scheduler (TBD)	Scheduling	Project Management Office	01/2018 - 06/2020	100	Y
Project Admin (TBD)	Administrative	General Services	01/2018 - 06/2020	100	Y
Design Engineers (TBD)	Engineering	Engineering	07/2015 - 12/2019	100	Y
Project Engineer (TBD)	Engineering	Engineering	Thru 06/2020	100	Y
Field Engineers (TBD)	Engineering	Engineering	07/2015 - 12/2019	100	Y
Work Planners (TBD)	Work Planning	Work Management	07/2015 - 12/2019	100	Y

B) External Resources

Resource Name	Skills Needed	Organization	Timeframe Needed	% of FTE Needed	Commitment Obtained (Y/N)
Bob Hansen	Engineering	J. Givoo Consultants	Total Project	25	Y
Isidor Kerszenbaum	Subject Matter Expert	Technical Consultant	Total Project	25	Y

C) Internal/External Stakeholders

Stakeholders	Current Assessment	Impact Analysis
Operations	Supportive	Execute project to improve reliability and safety of DCPP Unit 2.
Siemens	Supportive	Complete main generator stator Unit 2 upgrade.
Customers	Supportive	The project will improve the reliability and safety of the operation of DCPP.

IV. Executive-Level Diagram

Below is a cross-sectional view of the Unit-2 main generator and its sub-components.