the center for negative carbon emissions

SRP/ASU Performance Execution Plan for 2019/2020 School Year

The Joint Research Program

Ira A. Fulton Schools of Engineering

Arizona State University

"Design a cluster approach for Tiburio collectors to provide a continuous feed of enriched CO_2 upgraded to 95% CO_2"

<u>Team:</u>

Principal Investigator: Klaus S. Lackner

SRP Liaison: Chico Hunter

& Alejandra Mendez

ASU Project Sponsor: William Brandt

Chief Design Engineer: Allen Wright

Process Engineering Manager: John Cirucci

Project Manager: Robert Page

Chemical Engineering Student:

Mechanical Engineering Student:

Business Finance Student:

ASU Support:

Due Diligence Lead:

ASU DAC Plan for Salt River Project; School Year 2019- 2020

Background Statement

During the 2018/2019 SRP Sponsored Joint Research Program, ASU developed engineering and supporting documentation for CO_2 Direct Air Capture (DAC) collectors designed to capture 100 tons/day and convert the captured product to a 95% enriched CO_2 stream. The engineering design effort used an air sweep gas for an intermediate product of CO_2 enriched air, that proceeded to a CPU (compression and purification unit) for 95% enrichment. Two years of joint SRP/ASU collaboration has progressed toward an optimized capture design integrated with downstream processes to enrich and upgrade CO_2 for commercial product applications. During 2018/2019 ASU completed the engineering required to group CO_2 capture devices into skids and clusters as a stepping stone to large scale capture application and designed a concentration and purification system that can provide ~95% CO_2 stream from the initial 5% CO_2.

The next step is to optimize the design, engineering and modeling that integrates the CO_2 capture by the Tiburio through the optimization of the harvest using a vacuum application. The team will further the CPU design including modifying the CPU to act in conjunction with Tiburio vacuum harvest. The ASU team will also investigate and analyze the economics of capture vs. potential market within the next five years, specifically looking at direct air capture for specific applications such as transportation and energy production, and to consider various other end uses for the captured CO_2.

The team will do analytical work on experiments that might be proposed to illuminate the process characteristics of vacuum-driven recovery, vapor flow in a low-pressure chamber and perform analysis of alternate sorbents. These lab scale testing concepts will be fleshed out during the next project cycle. And potentially funding will be sought to perform the experiments.

1. Plan Going Forward

1.1 Team

Form a team of students supported by ASU to work in conjunction with SRP to produces various designated deliverables and reports. The three students would ideally include a mechanical engineering student, a chemical engineering student and an economics or MBA student.

a) ME or other Eng. b) Chem E or Physics c) Econ, Finance or MBA

1.2. Objective for the '19/20 ASU/SRP Project – Engineer a fully functional CO_2 Capture system from field capture through concentrated CO_2 to market application.

a) Optimize the Tiburio, the Cluster and the CPU designs

b) Upgrade the CO_2 capture to utilize vacuum removal in the regeneration step

c) Expand the economic analysis, including timing and market analysis

d) Develop the elements of one to three experiments

2. Statement of Work/Scope.

The ASU team proposes to build off the success from the last two years with an expansion of the work on the CO_2 capture design to include engineering work on the integration of the Tiburio & CPU allowing for a vacuum system, and the development of CO_2 to a commercial product &/or sequestration. The ASU CO_2 Capture device creates a continuous stream of low vapor pressure CO_2 that has been engineered through a compression and purification unit that starts with a sub-atmospheric partial pressure of CO_2, ultimately to produce compressed CO_2 stream at >95vol% with low oxygen and water vapor content. It is assumed the CO_2 Capture devices would be used in a multiple device configuration co-located with a CO_2 CPU array thus providing a viable product stream of CO_2 for product uses (or sequestration) at a large variety of geographic locations. The proposed project would design/engineer the process for product delivery including equipment, flows, volume and cost. The project would consider known and described uses of captured CO_2, analysis the probable successful application of each and report on the most likely uses to be applied in the next decade. To support design concepts the project will address potential experiments.

2.1 Design Basis

Create a Design Basis document that will include:

- Bespoke design utilizing a vacuum harvest for the Tiburio units.
- Enhanced efficiency and improved design of Tiburio, Clusters and CPU.
- Determination of the ideal means for humidification and CO_2 recovery from the Tiburio,
- CPU internal components to be modified for vacuum operation
- Individual equipment best suited for new "first of a kind" equipment be incorporated
- The students will need to consider a host of systems engineering challenges and produce a cohesive systems design and flow diagram of collectors through the CPU and end use processes.

2.2 Design Charrette

The team will hold two design charrettes to consider the specifications for the process model. The purpose of the charrettes is to (1) consider design alternatives; (2) settle on a process flow and an overall design focus for integrating capture (3) optimization of the CPU system design and material selection. The Charrettes will also consider how markets for CO_2 might develop, how market development will impact timing, and what value might be placed on CO_2 capture over the next ten years.

2.3 Design of a Product System

As the specifications and performance details including hardware from CO_2 collector to purification system has been determined in the two previous SRP projects, the next step would include design and optimization of a product delivery stream that would consider sequestration, agriculture, CO_2 product lines and pipeline ready methane.

End to end design and engineering are essential to commercial plans to take the ASU/SRP capture system forward. There needs to be an understanding of capture rates and product delivery at scale. The third-year project would respond to the engineering challenges that will develop as the fully integrated end to end process is designed. Further the project will address what the product might cost and how that value for the product will fit into the future requirements for CO_2 capture.

Currently each collector is compromised of the air collector system, the regeneration chamber, and the CO_2 transfer units. Each collector is operated in a batch process to collect and deliver CO_2, and feeds product streams to a CPU. Collectors and the CPU represent a train, the smallest, repeatable unit producing ≥95% CO_2 at 20 bar. The production capacity of a train will be re-evaluated, informed by 2018-2019 project learnings, and different requirements imposed by vacuum operation. Vacuum CO_2 removal could allow each collector to operate autonomously, eliminating constraints that were imposed by the air-sweep cycle. A “cluster” may not have any meaning in light of that, unless it is cost-effective to have split-scale low pressure and high pressure processing. During the design basis phase the team will determine cluster and train scale based on:

- Recovery cycle strategy (e.g. initial evacuation, CO2 rinse, pressure equalization);
- Number of combined collector streams required to provide pseudo-steady-state output;
- The practical suction flow capacity for appropriate vacuum compression equipment;
- Relative flow capacity for appropriate downstream high-pressure CPU equipment.

The team will first work through a Design Concept, placing the conceptual ideas in a Design Basis document. After the team has reviewed and agreed to the Design Basis the team will proceed to engineering the integrated concept and associated supporting equipment.

The design & engineering will need to include additional control system hardware, firmware and software for operation. The Design feeds the economic modeling which will also include analysis of the market and an evaluation of the convergence of Tiburio production schedule and market.

Finally, as the design work develops new questions the team will draft recommendations for proof of concept experiments to be proposed either to SRP or others seeking funding to carry out the experiments.

2.4 Design Review and Selection

The team will develop design choices as to how to handle the development of a fully integrated process from capture to product utilization. The project would consider the change to vacuum, the creation of alternative (possibly ASU designed) equipment for the CPU, and the engineering needed for product conversion. The project will do a complete cost, market and economic analysis and the value of the resulting products for various end-use applications. It may be necessary to consider cost saving measures such as operating on intermittent energy sources (off-peak solar) in order to arrive at a competitive price point for some products. The team will establish target benchmarks.

Design review will be formalized.

⇒ Values based decisions

⇒ Decision making, tied to the vision

⇒ Decision making priority

⇒ Make decisions and move on:

⇒ Focus on product commercialization

⇒ Measurement and tracking

2.5 Create 2D and 3D Drawings

The completion of 2D and 3D drawings for the design and calculation modeling of the functioning process flow diagram. The drawings will indicate the overall approach to creating an integration from captured CO_2 to product. The project will develop a layout and include major equipment. Drawings for the entire system from CO_2 capture to product will focus on system configuration and flows. The drawings and flow diagrams will cover the individual units and general arrangement drawings of an integrated system. Specifications will be developed in association with the drawings. Specifications and P&ID's will include major equipment.

2.6 Full Integration of the Design

ASU will design the fully integrated system, which will include automatic coordination between multiple collectors and CPU that in concert optimizes performance. Control systems design will be expanded to control the overall integrated process, including engineering sensors and control algorithms built into the individual sub-units within the cluster and CPU, with consideration of downstream integration for various end-use applications. Work on integration will start in month 5 through month 9. This effort will focus on performance and build in consideration of potential safety constraints including mitigation steps for safety concerns. As the design details become established, cost estimates for the all components will be developed.

2.7 Full Materials Review

Materials decisions need to be made in conjunction with design progression. This year specific material recommendations will be made for all aspects of the Tiburio and some portions of the CPU. Materials need to reflect functionality, safety, projected lifecycle, cost, availability, fabrication ease and impacts on O&M. Target materials that meet the specification requirements and are also light, less expensive than alternatives, and sufficiently strong to function 30 years.

2.8 Create Maintenance and Operational Draft Process

The need to fully grasp how O&M is impacted by design and alter design choices for better O&M results. Design will adjust based on the cost of fabrication balanced with the cost and projected O&M. Design should consider how O&M functions are impacted by design and how future O&M

might be reduced through functional improvements – the design needs to be forward looking allowing for functional and cost improvements.

2.9 Cost Analysis of the Integrated System

Based on the previous results for the CO_2 Capture devices and CPU plus the introduction of an end-use component the new system will be integrated to create a capture through end-use design. And the project will complete the costing of the overall capture system to product. This process will include energy and material costs and provides a first level life cycle analysis of the design.

2.10 Economic Valuation and Analysis of the Captured CO_2

The Analysis section and report would include conclusions as to likely market scale over the next ten years. The study of market potential for different end uses, would include a survey of the market and a literature review. The consideration of costs during the coming decade would focus on potential end uses and apply likely valuations-based estimates from the literature and student analysis (EOR, fuel conversion, deep underground storage, merchant market). The valuation of end product use would be compared to the estimated total price of the Tiburio DAC system. The end markets might also be scaled in terms of the offset market such as: US power sector emissions, transportation sector emissions, building sector emissions. The analysis will use and update the Data Model.

2.11 Create a Set of Experiments to validate Engineering to Date

Develop experiments that will provide validation for the design and engineering work. Create experiments including procedures and materials list for the performance of validation experiments, either lab or field. Draft proposal(s) to raise funds for some or all of the recommended experiments.

3. Generate a Technical Report Summarizing the Results

The final stage of the project creates a technical report delivering a complete design model for CO_2 capture through product production. The results will be collated from the previous and current efforts from the SRP joint research program and further used to develop a detailed cost analysis and comparison valuation for the next step in development of the ASU DAC project. The final report will be presented to SRP along with a power point deck. An estimate of the potential carbon capture cost including product cost from capture and an evaluation of CO2 capture value during the next decade will be the focused result of the proposed research.

3.1 The proposed project contributes to our knowledge base and advances engineering science in CO_2 DAC Technology and the Recycling of Captured CO2 into Products

Integrating past advances and developing a system design that will provide CO_2 capture structure from air to product would advance the concept of direct air capture. It will advance the technology development at ASU, where the integration of clusters of the capture system, the CPU system tied (through this project) to a product creation system. The project will provide a commercial path for CO_2 capture including an analysis of valuation and costing during the next ten years. The

ASU Work Product/Confidential

opportunity for CO_2 capture to proceed is dependent on offering a fully integrated design with an understanding of how the cost of the system will relate to market valuation.

3.2 Advances SRP's Sustainability goals

A successful outcome of this R&D project would open a new innovative approach to achieving SRP's sustainability goals. The proposed project would provide SRP with the conceptual design and preliminary engineering of an integrated CO_2 capture, concentration system through to product creation. Direct Air Capture offers the most viable to meeting future CO_2 capture goals.

4. Fixed Cost Budget $70,000

5. Schedule – Appendix A

6. Plan Approach Outline

The Team will perform pre-project work to organize the areas of the Project so that when the Project "Kick off" in September occurs, organizing work will have been completed allowing the project to begin in full in September.

Phases:

	Aug	Preliminary work
1.	Sept/Oct	Planning: Hire students. Set Goals. Detailed plan & schedule
2.	Nov/Dec	Design: 1st results and re-set. 1st Charrette
3.	Jan/Feb	Draft: 1st draft reports.
4.	Mar/Apr	Product: Draft conclusions. Presentation to SRP 2nd Charrette
5.	May	Final: Final report and deliverables

Preliminary Work August

Start with:

- Plan Outline – Project Execution Plan (with schedule, budget and measurement)
- Interview and hire students
- Gather material from last year for team to work from
- Presentation to ASU Internal Team
- Charrette and other presentations dates
- Design Basis; revision outline with the addition of Cluster

Steps for Phase I – Planning *Work on the analysis and investigation* Sept/Oct

- *Build a Plan*. The Plan will include the elements of a Project Execution Plan including budget, schedule, deliverables and a DOR.
- *Preparation* – Prior to Plan completion review material from previous years' work and incorporate as appropriate. Divide the tasks among the students and develop list of potential deliverables.
- Assignments – Student roles by Topic
  - *Process Design*
  - *Mechanical Design*
  - *Economic Analysis*
  - *Draft proposal for experiments*
- *Project Kick Off* - The Team will hold a meeting to start the project reviewing key documents and agreeing to the scope, timeframes and deliverables.

Steps for Phase II – Design *Develop early results & analysis* Nov/Dec

Topic #1 - Optimize Tiburio, Cluster and CPU Design

Analyze current design for potential improvements

- Modify the design based on change to vacuum
- Draft new PFD that fits vacuum concept
- Recommend materials (Sorbent, Chamber, & Discs)
- Begin draft of a revised specification and Design Basis
- Draft 2-D and 3-D drawings of all aspects of the revised design
- Draft flows and energy balance for all modifications

Topic #2 – Re-design the Tiburio for a Vacuum CO_2 removal

- Consider flows and connection to the CPU
- Develop initial ideas to simplify the process, increase harvest, and reduce costs
- Design application, fabrication and operation should be addressed
- New set of drawings and flows
- Re-Draft the Specification

Topic #3 - Economic Analysis

- Revise and update cost model
- Evaluate cost reduction over time due to increase production

- Build a financial model based on possibilities for market use. Model will include the likelihood of a tax, pricing, impacts of CO_2 capture implementation.

Topic #4 - Draft proposal for experiments

- Draft ideas for experiments
- Budget for experiments
- Draft proposal to ask for experiment funding

Steps for Phase III – Draft *Build each Topic 1st products* Jan/Feb

Topic #1 - Optimization

- Device Challenges to consider
  - Water Application
  - Vacuum design
  - Disk architecture
  - Vapor flow pattern
  - Materials of construction
- CPU
  - Integration with collector operation
  - Equipment scale
  - Heat and water integration
  - Layout
- Sorbent
  - Water management
  - Required water quality
  - Sorbent architecture
- Include in the work
  - Design
  - Fabrication materials, parts and cost to fabricate
  - Operational characteristics narrative (includes maintenance) and costing
  - Draft Specification and accompanying Design Basis (may be one document)
  - Capital cost with fabrication, shipment/install cost, and O&M cost
  - Define operation, maintenance, safety considerations and product delivery

Topic #2 - Vacuum CO_2 removal

- Finalize the skid design based on Topic #1 final
- Process flow steps
- Equipment cost– all aspects
- Skid mounted design modifications
- Fabrication, shipping and operations cost up to product delivery

Topic #3 – Economic Analysis

- Build from last year's data model
- Define expected product cost
- Full description of the market
- All cost analysis from material purchase through fabrication and shipping
- Operations and maintenance costs
- CO_2 as a product, investigation and analysis of captured CO2 market and value over the next decade.
- 5% and 99% values and market size
- Market within the next two, five- and ten-years including market growth by stages and why
- Value distribution by market
- Draft Business Model
- Data Model upgrade

Topic #4 – Propose Experiments

Steps for Phase IV –Product *1st set of conclusions and preliminary results.* Mar/Apr

Develop draft conclusions and produce reports on results and findings

Topic #1 - Optimize Tiburio and CPU Design

- Integrate the design
- Finalize the Drawings, Specifications and Design Basis
- Draft presentation of the Tiburio including calculations related to production
- Analysis of O&M vs. cost and design decisions

Topic #2 - Vacuum CO_2 removal

- Integrate the design

- Finalize the drawings and specifications (Spec. will serve as Design Basis)
- Draft report on cluster configuration and options considered
- Facility layout

Topic #3 – Economic Analysis

- Complete the investigation and analysis on CO_2 as a product
- Market value, market growth and market timing
- Best to least likely markets for CO_2 products over the next decade
- Business Model should provide an integration of the overall project results and decisions
- Fully cost, describe operation, and provide calculations

Topic #4 – Proposed Experiments

Topic #5 – Preliminary Safety, Health and Environmental Plan

Steps for Phase V – Final May

Final results and report

- *Optimize Tiburio and CPU Design*
- *Vacuum CO_2 removal process cycle*
- *Economic Analysis*
- *Draft proposal for experiments*

7. Project Management

The project team will be a matrix organization. The project team is a mixture of ASU faculty, ASU students, SRP and contract personnel structured to best serve the needs of the partner's efforts towards a successful conclusion of the Project.

1. The Execution Plan, drafted for the Proposal, will be updated periodically during the project execution period.
2. Scope management will be the responsibility of the Project Director/Principle Investigator (Klaus Lackner). The Project Director will establish and approve documentation, including deliverables, reports, measurement, project scope, deliverables, and work performance measurements.
3. Budget - Overall draft budget is $70,000.00
4. Reporting & Communications

- Communication Requirements
    - Project leadership will speak daily
    - Project report monthly
    - Safety will be a part of meetings
    - Weekly Student team meetings
    - The project team will share openly
- White Papers and Presentations
    - The Project team will develop for distribution various presentations and white papers
    - All presentations and white papers will be reviewed prior to outside distribution.
    - A sign off and comment review protocol will be used for outside papers and presentations to assure internal review.
- Conduct
    - Speak honestly, openly, forth rightly & with respect
    - The Project Director will take the lead role in reviewing, approving and communicating design decisions
    - The Executive Director will take the lead in overall logistical direction and student functioning roles on the team
    - The Project Manager will take the lead role in ensuring effective communications on this project.
    - The Chief Design Engineer will take the lead in approving and communication engineering decisions
    - The Director of Logistics will assure that communications protocols are followed and be responsible for communication to appropriate departments within the University

8. Deliverables

One) Performance Execution Plan (PEP) Phase I

Two) Charrette results

Three) Monthly Reports

Four) System energy and material balance

Five) Revised Tiburio & Skid Mechanical Design

Six) Revised CPU PFD and Major Equipment Design

Seven) Drawings, calculations and specification

Eight) Value Analysis

Nine) CO2 flow pattern from capture to product delivery

Ten) Material selection decisions

Eleven) Business Model with Cost & Economics

Twelve) Economic Analysis and Market Evaluation

Thirteen) Presentation for SRP

Fourteen) Results Reports

9. Impact of Results

- An estimate of the potential carbon capture cost resulting from the proposed research
- Draft conclusions on the economics of carbon capture, the timeframes for captured CO_2 pricing and potential pricing by market
- Results from design of capture dynamics
- The proposed project contributes to our knowledge base and advances engineering science in DAC technology
- Integrating past advances and developing a functional design for post capture concertation feeds
- Advances SRP's Sustainability goals
- The proposed project establishes the SRP - ASU team as a proactive leader in sustainable energy development
- In the interaction with SRP, our goal is to provide joint leadership between SRP and ASU in finding innovative solutions to complex issues relating to climate change.
- The proposed project engages graduate students in an applied learning experience and advances educational opportunities at ASU
- From an ASU perspective, this project provides an excellent opportunity to engage students into an advanced capstone project that crosses the spectrum of engineering disciplines.
- Provides excellent educational opportunities on a cutting-edge project that has demonstrated already that it can excite the enthusiasm of students.
- The immediate benefits to SRP and ASU are an increase in collaboration between the two ASU groups which have similar goals and the combination may open new opportunities.

- SRP benefits from the development of technology options for CO_2 reduction
- The project aligns well with efforts on utilizing captured as recycled carbon and storage

10. Measurement

1. Safety — No lost time accidents. Safety included in design and operational considerations
2. Budget — Remain within the fixed budget amount
3. Schedule — Complete deliverables within Plan dates
4. Product — Deliverables are met
5. SRP Reports — Monthly reports are complete and timely
6. Students — At least three students are engaged for two semesters
7. New results — The project produces first of a kind design
8. Product — Products will be completed in a manner in keeping with industry standards

Appendix A. Schedule

Tasks	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Team Formation & Plan	Complete				Plan review				
Design Rev. & Mods.	Agreed on design dim.								
Calculations & Measurement		Tiburio		Cluster		Concentration			
Tib. Vacuum & Mods Schedule									
Design Basis draft									
CPU Plan & Schedule									
Vacuum process configuration	CP for sizing								
Investigate vacuum equipment		Sizing							
Train scale and product spec									
Water delivery strategy			Tie to design mods.						
System PFD									
System E&M balance									
CPU equipment sizing									
CPU equipment costing									
Drawings (Tiburio)		3-D	2-D						
Charrette #1									
Build a mock up model		Disk model							
Design Report		1		2		3		4	
Process Flow - Tiburio			Tib	Cluster			w/ CPU		
Tib. Cost Cap & O/M		Model built	BOM	O&M					
Economics & Market						Marketing & Econ Chapters			
Drawings - skid									
Drawings - facility layout									
Skid Cost					Cap.	O&M			
Charrette #2								11-Apr	
Cost & BOMs Tiburio		Materials		Capital		O&M	Total	Final edits	
CO2 Value & Timing									
Material Recom.									
Update Data Model									
Market & Products									
Financial Model		Model Built		Review Model and edit					
Business Model									
Experiments					Recommendations				
SRP Presentation & Report									to SRP

Appendix B Budget

Appendix C Design Review

Design Review Process

1. Design Basis Document rewrite should begin at the start of the project The Design Basis Document allows the Team and SRP to refine the understanding of the design scope and the operating/performance preferences. The Design Basis Document will allow for a thorough review of the and discuss any variations/options. Based on team input the Design Basis Document will be modified and a final review will provide documented agreement on the scope of the Project. A well-managed Design Basis Document review allows for

changes early in the project at little or no cost impact to tailor the project to the expectations.

2. Design drawings and engineering documents will be reviewed by the Team throughout the Project. A list of design drawings and engineering documents to be forwarded for review and approval has will be provided and will be reviewed during the Design Basis Document development. Input on these specific documents are expected throughout the project, with every effort made to receive input early so as to not impact cost and schedule. All other documents will be provided to SRP for information only. Team will work with 3-D drawings and model throughout the project. The modeling will be used for both engineering and construction. Design quality control requires a discipline engineer review of all engineering work. All reviews are documented, and documentation retained. Any substantive comments within a review must have a written response and an acknowledged closure by the reviewer or a higher level of management. All reviewer comments and closure are reviewed on a monthly basis to assure closure has been adequately addressed.

3. RFI process will be a number-based tracking system with 1) ID Project, 2) ID discipline (electrical, mechanical, etc.), 3) indication of the Organization asking the question, 4) sequential number, and 5) track by number with an open/closed designation maintained for all RFI's issued. The RFI process will include and target response time, distribution requirement, and process to tie RFI's to their impact on drawings.

4. Reviews will be completed by the Project Director, Engineering and the PM Reviews will be scheduled and tracked. All reviews will have a start and end date. The drawing number system will be used for reviews and comments during review.

5. Design functional listing:
    a. Preliminary (30,60,90%)
    b. Issued for Report
    c. Equipment Take-offs
    d. Commodity Take offs
    e. Drawing Sequence
    f. Specifications
    g. Request for Quotation
    h. Vendor submittals
    i. Vendor Log
    j. Engineering Action List
    k. Red Lines

Engineering Submittals

Proper handling of design and engineering submittals, control of incoming and outgoing information, and clear communication with the subcontractor are required to achieve engineering management goals. The below lists types of engineering submittals and types of checks to be performed. Submittal logs will be used to track incoming and outgoing engineering and submittals to ensure that the documents are reviewed and returned in a timely fashion so as not to impact the design and construction schedule.

Types of Engineering Submittals
Design Basis/Design Criteria
Studies/Reports (e.g., Geotechnical)
Calculations (e.g., load calculations)
Drawings (P&IDs, equipment layouts, plot plans, civil detail drawings)
Models/Databases (e.g., piping model)
Lists (equipment, line, valve, electrical load, motor, instrument)
Estimates (e.g., man-hour, price, cash flow)
Datasheets (e.g., process, equipment)
Specifications (equipment, material, and system manufacturing specifications)
Manuals and Procedures (test procedures, O&M manual)

The PM may use the *Drawing Review Checklist* and the *Vendor Data Review Checklist* to ensure consistency in reviewing the submittals. The intent of the checklists is to help prevent errors of omission, since the extent of the technical packages is quite broad.

Design Input and Clarifications

The PM will respond to the subcontractor's requests for design-related input and clarifications in accordance with the *Contractor Communications Protocol*. The PM will address the inquiries in a prompt manner to prevent delays and subsequent schedule slips.

Value Improving Practices

If any Value Improving Practices (VIP) are identified they should be communicated to the PD. An approval needs to be obtained before implementing the VIP. Any associated cost and schedule savings should also be passed onto the Project via deductive change orders.

Design Nonconformance's

The Director should be notified of design nonconformance identified.