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In partnership with:
US DOE/NETL
Bechtel Corporation

Coal-Fired Direct Injection Carbon Engine (DICE) Compound-Reheat Combined Cycle (CRCC)

Contract No. 89243319CFE000025
Coal-Based Power Plants of the Future

Appendix A: Project Execution Plan Presentation

Contents

1. Project Structure and Framework

In the present situation, DICE ("Product") is an integral part of DICE CRCC ("Project"), a novel concept, requiring development of key components

The development of DICE ("Product"), which is an integral part of a DICE CRCC power plant ("Project"), is presented. The DICE CRCC consists of fuel preparation and post-combustion capture (PCC) blocks which is actually a "Project within a Project". This presentation provides the Project Structure and Framework:

- **DICE CRCC**[1] is a novel power plant concept for burning a coal-based fuel
- While there is a ***need*** for a small, modular and flexible power plant to burn coal efficiently and cleanly
- There is no readily identifiable market **demand** for it (in the USA and other developed countries)
- Coal as a power generation fuel has a negative image
- Major engine OEMs do not plan to invest in this technology
- There is ongoing research in DICE technology (CSIRO in Australia)
- In cooperation with Chinese engine manufacturer (licensee not an original OEM)

1 DICE-Gas Turbined Compound Reheat Combined Cycle (Direct Injection Carbon Engine – i.e., coal-fired diesel engine)

PEP covers prerequisites and acquisitions which are based on key technology innovation, market opportunity, specific components, and development

- Under the light of the present situation stated above, the following **Project Execution Plan (PEP)** is based on following prerequisites and assumptions:
- A new and positive image for coal (already so in Asia – opens up the door to US technology export)
- Market opportunity to entice major engine OEMs into their own R&D and/or cooperation with third-party component R&D organizations (e.g., CSIRO in Australia)
- Fuel injection system basic design already complete
- Customer identified
- Site selection and logistics in place

This PEP is exclusively prepared for the DICE component of the DICE CRCC

PEP addresses key prerequisites and acquisitions related to DICE technology, fuel preparation, and differentiates steps which required additional R&D

- Coal feedstock selection – current preferred study is using PRB coal, which is not the ideal feedstock for widespread deployment of the DICE technology (difficult to store, spontaneous combustion)
- Fuel preparation technology in place (which is predicated upon selected coal feedstock)
  - Grinding/micronizing
  - Washing/cleaning
  - Stabilization
  - Storage
- These steps do not require R&D ***per se*** (they are not identified as ***technology gaps***)
- However, a careful front-end study is needed to settle on these two items before proceeding with the power project

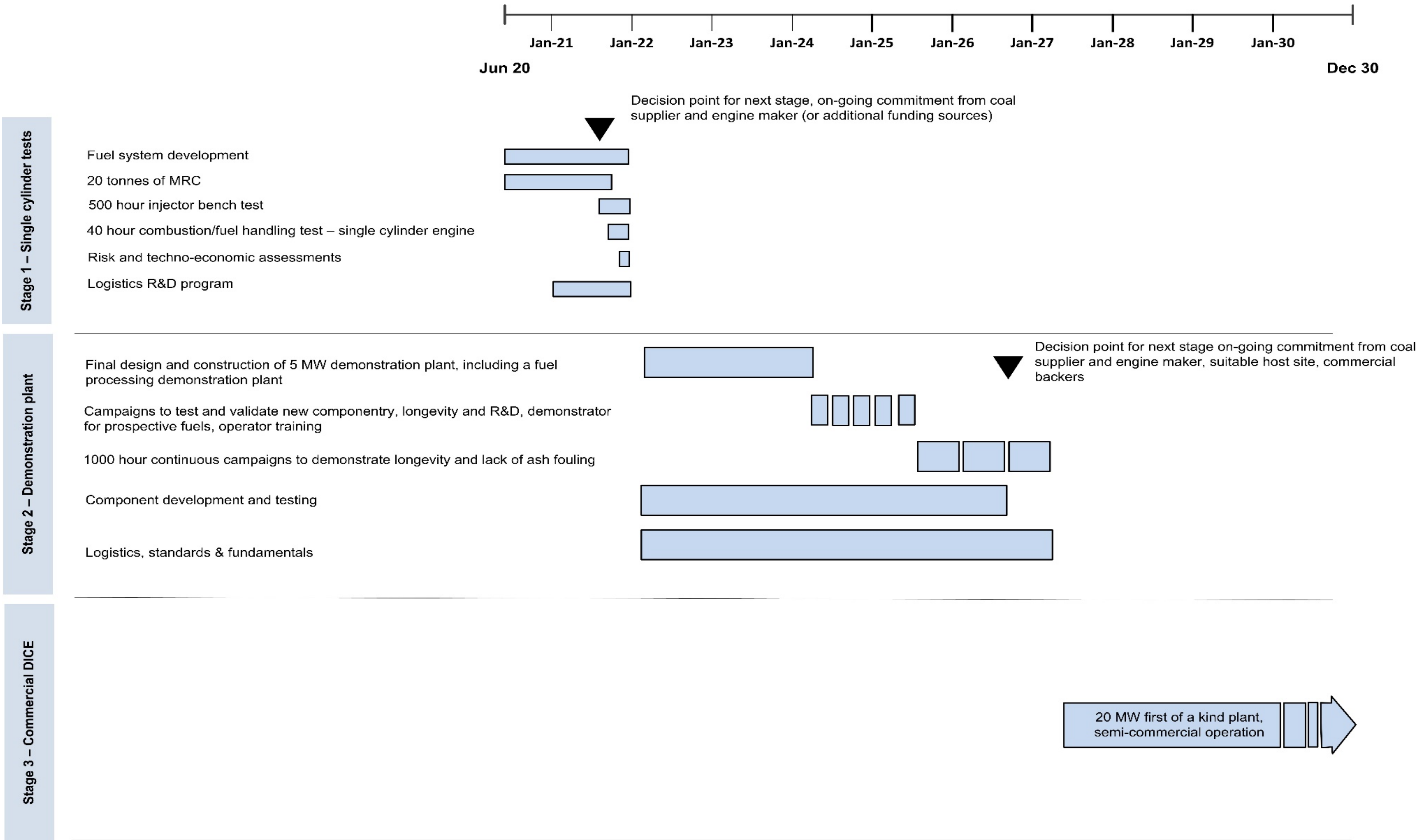
Project overview focuses on the scope related to DICE, key objectives, project execution strategy, permitting, cost and schedule, and other related areas

- Client and Project: TBD
- Contract Basis and Terms: TBD
- Scope of Work: Design, development and manufacturing of a **Direct Injection Carbon Engine (DICE)**
- Project Objective: Delivery of multiple DICE with requisite BOP ready for installation on DICE CRCC construction site (“The Product”)
- Project Execution Strategy
- Project Cost and Schedule

DICE product development pathway requires definitive focus on identifying key OEMs, business case to OEMs, building test facility and risk review

- Should be already in place
  - Fuel selection and assessment
  - Fuel supply secured
  - Basic fuel design completed
- "Piggyback" on existing work (DOE and others)
- Identification of key OEMs
  - Stock engine
  - Fuel injector
- Business case made to the OEMs
- Forming a consortium with an OEM
- Building a test facility
- Test campaign
- Risk review

DICE PEP timeline covers a phased 10 year period leading to a semi-commercial DICE plant by 2030



Fuel development is expected take place concurrently as part of the Stage 1 test programs

2. Non-Commercial Component Development

Product definition of DICE covers engine block (cylinder liners, fuel injectors), air starter, fuel supply system, and other key components

- The product is one DICE comprising
  - Multi-cylinder engine block
    - Crankshaft and main bearings
    - Pistons and connecting rods
    - **Cylinder liners and headers**
    - Valve train (camshaft w/ valves)
    - Flywheel
    - **Fuel Injectors**
  - Air starter
  - Synchronous a/c generator
    - Excitation system
    - Oil skid
    - Flexible coupling
  - Engine coolant system
  - Lube-oil system
  - **Fuel supply system**
  - Exhaust gas system
  - Control system

Majority of DICE product is "off-the-shelf" and there are other product components requiring R&D which consist of several key components

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  - Multi-cylinder engine block
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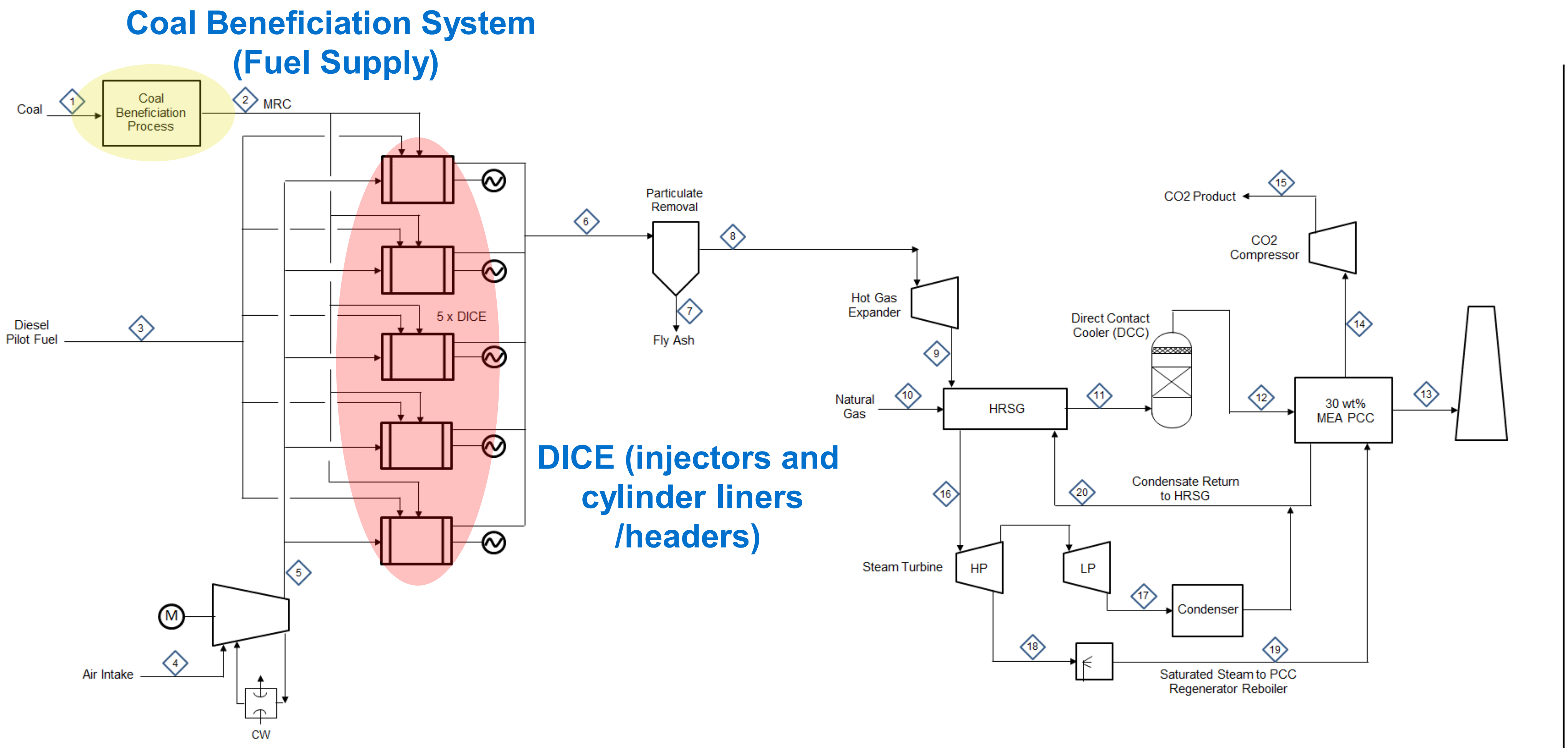
  - Exhaust gas system
  - Control system

- To a great extent, "off-the-shelf"
- Several key components require R&D or further testing and validation

Overall DICE CRCC Process Flow Diagram



Components require R&D

Components require testing and validation

Technology gaps for the product only cover fuel-engine interactions, fuel injector design, combustion stability, exhaust valve wear, and fuel system

- Fuel-engine interactions
  - Special coatings to protect cylinder liners, headers and valves
- Fuel injector design
  - Air-blast atomizer
  - Atomizer nozzle longevity
- Combustion stability
  - Ignition delay
  - Diesel pilot
- Exhaust valve seat wear
- Fuel system design to eliminate blockage
  - Fouling
  - Corrosion

The DICE product R&D requirements which must be addressed consist of specific key components which require further advanced development efforts

- Engine atomizer development
- Ceramic materials development
- Injection configuration development
- Piston shape optimization
- Ducting optimization
- Fuel filtration

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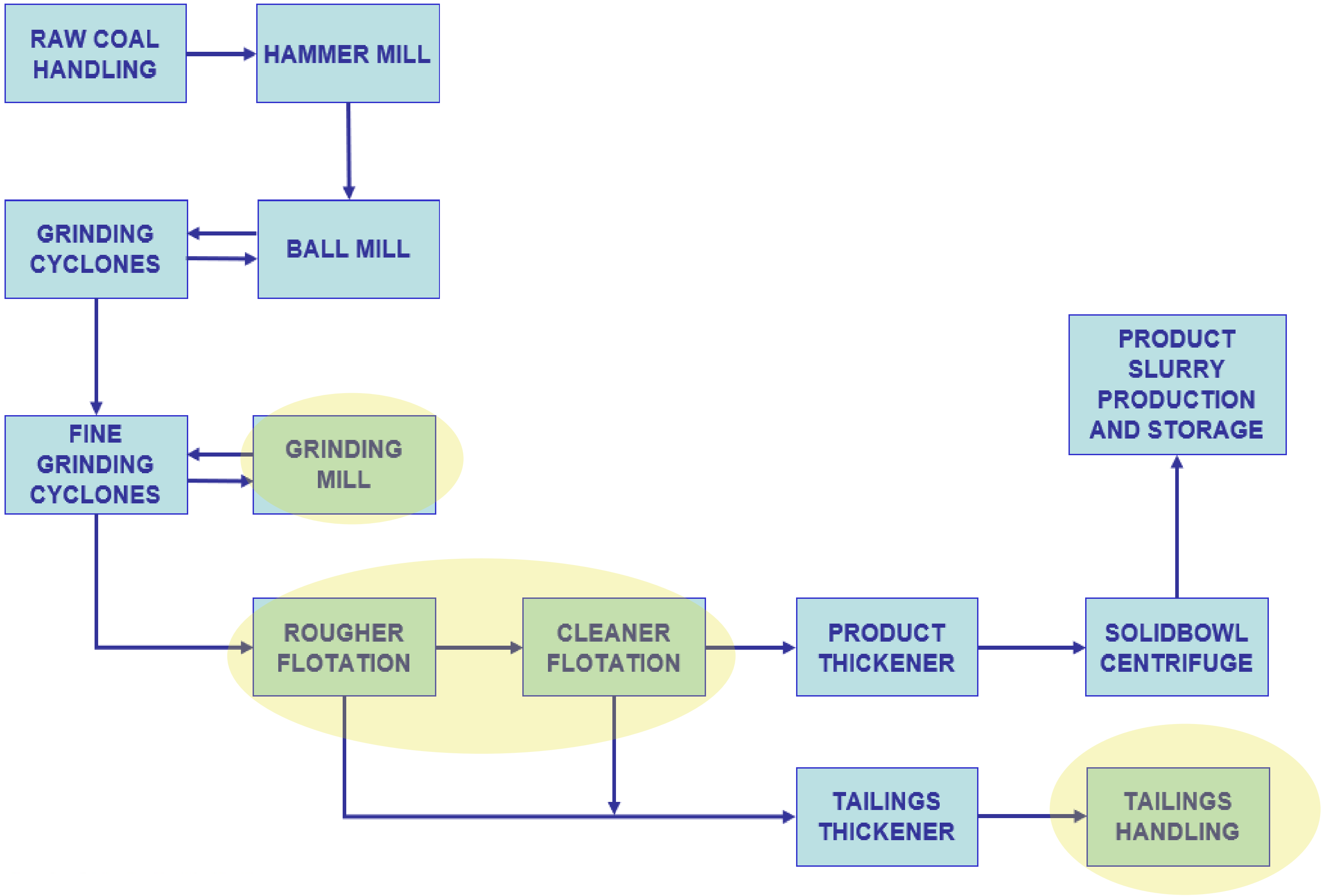
Coal Beneficiation Process Flow Diagram



- No components are technology gaps *per se* since each plant unit operation of the flowsheet is currently commercially available but application to coal is novel
- Testing opportunities on coal are limited (market-driven)

Further testing and development required on specific coal types for optimal yield and efficiency

- Fine grinding mill
  - Available technologies include impact and attrition mills
  - Selection of most suitable grinding technology depends on various factors
  - Factors include product size, feed size, energy consumption
- Ash Removal (via flotation)
  - Different flotation technologies available with different energy and reagent input requirements
  - Low ash concentration in product coal (2 wt% db) is a challenge
- Tailings Disposal/Utilization
  - No market value in slurry form
  - Additional energy/cost to process (dewatering, briquetting)
  - Function of product yield (< 50% for PRB coal)

Feed coal selection and development of centralized coal beneficiation plant are vital to success of DICE CRCC

- Feed coal selection
  - PRB coal shown to be not suitable in current pre-FEED study
  - Low product yield results in large as-received feed requirement and tailings for disposal
  - Bench-scale tests needed on various coals to establish and select feed with best available yield
- Centralized beneficiation plant
  - No economy of scale for modular beneficiation plant at every DICE CRCC plant
  - Centralized beneficiation plant maximizes capital and labor effectiveness
  - Need to consider product stability at delivery (slurrying process on-site?)
- Coordination with DICE OEM
  - Need to work in close coordination with DICE developer
  - Ash content, sulfur content, rheology, among other properties, need to be established between DICE and coal beneficiation developers
  - Intend to develop this coordination under DOE CoalFIRST Critical Components development program

Development Needs and Work Plan

- Feed coal analysis and selection
- Coal grain analysis
- Crushing and grinding test work
- Flotation tests
- Thickening and dewatering tests
- Rheology characterization
- Pilot plant operation

Details are provided in the report from coal beneficiation OEM Sedgman

3. Project Financing

Project financing assumptions for DICE–GT CRCC (Project) include TRL, equity, debt, and grants for pilot plant and a next-of-a-kind (NoaK) commercial plant

Key Project Finance Parameter	Pilot Plant	NoaK[1] Commercial Operation Plant	Commentary
Technology Readiness Level (TRL) [2]	5 to 6	9	▪ TRL assumes pilot project will be pre-demonstration phase and beyond bench-scale unit ▪ TRL for NoaK assumes advanced commercialization of technology and market ready for deployment
Type of Project Financing	Not Applicable	Limited Recourse or Non-Recourse	▪ Limited recourse wherein NoaK project assets are mortgaged or hypothecated or collateralized to lenders ▪ Non-recourse wherein NoaK project's EBITDA and cash flows provide debt service coverage (DSC) over entire duration of repayment of loans and supported by bankable offtake agreements
Debt : Equity Ratio (DER)	Not Applicable	60 : 40 or 1.5 : 1 70: 30 or 2.33 : 1	▪ Typical values are shown. Lower DER is for first 1 to 3 plants ▪ May vary depending on lenders requirements
Equity Sources	Venture Capital, Risk Capital, Project Sponsors, and Developers	Private Equity, Project Sponsors and Developers EPC and O&M Contractors	▪ Assumes equity investment is made into special purpose Project Company specifically set-up for the Project ▪ Equity sources execute Shareholders Agreement with SPC
Debt Sources	Not Applicable	Federal Government Loan Guarantee and syndication by Commercial Banks	▪ Pilot plant assumes no debt financing but only equity and grants ▪ NoaK commercial plant debt financed based on limited recourse or non-recourse financing. Debt is senior debt, subordinate debt, and working capital
Grants Sources	Federal Government State Government Non-Profits	Not Applicable	▪ Grants (e.g. R&D grants and project grants) assumed for pilot plant since technology is in pre-commercial stage ▪ Grants not applicable for NoaK plant which is an advanced commercialized stage

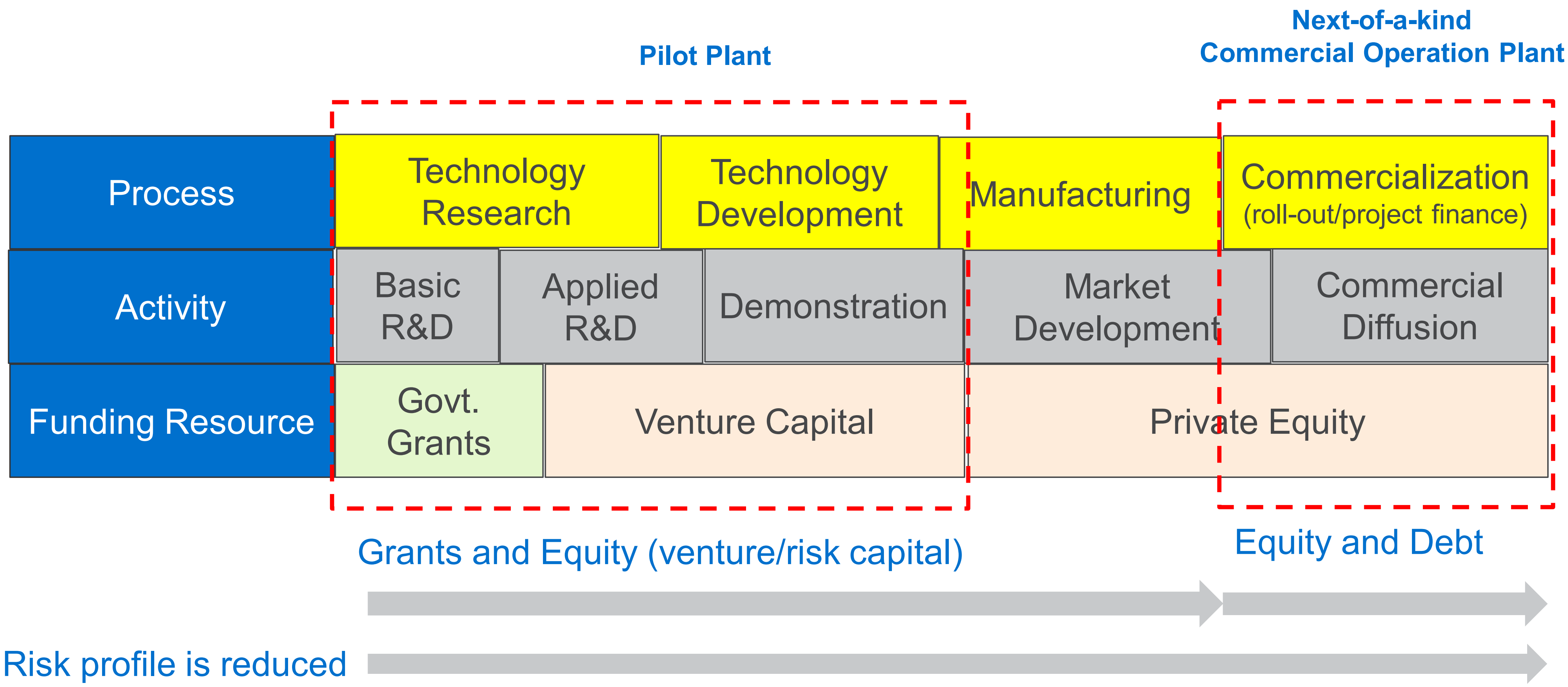
Notes:
1. Next-of-a-kind (NoaK) commercial operation of modular coal plant
2. TRLs defined based on USDOE's Technology Readiness Assessment Guide

Project financing parameters for both pilot and NoaK plant include fiscal/ financial incentives, economic/financial analysis, contracts, and key norms

Key Project Finance Parameter	Pilot Plant	NoaK[1] Commercial Operation Plant	Commentary
Fiscal and Financial Incentives	Subsides via grants, income tax credits (ITCs), accelerated depreciation, carbon credits (CO_2)	Loan guarantees, income tax credits (ITCs), accelerated depreciation, carbon credits (CO_2)	▪ At federal level and possibly at state level ▪ Both pilot and NoaK plants need to consider potential changes in regulatory framework, policy, and directives
Elements of economic modeling and financial proforma analysis	Capex, Opex, Total Installed Cost, Levelized Cost of Electricity (LCOE)	Same as Pilot Plant plus projections over economic life along with financial profitability indicators	▪ NoaK plant must also consider power tariffs, electricity merit-order dispatch scenarios, lifecycle assessment (LCA), and cost insurance, variable//fixed Opex, and working capital margin ▪ NoaK plant must include payback period, internal rate of return (IRR), rate of return on equity (RROE), net present value (NPV) and debt service coverage ratio (DSCR)
Requirements for transaction contracts	Technology license agreement (if req'd.), EPC and O&M Contract	Same as Pilot Plant plus fuel supply agreement (FSA) and power purchase agreement (PPA), agreement for purchase of carbon (CO_2) credits	▪ Pilot plant and NoaK plant's EPC contract must consider "wrap" to cover warranties and guarantees ▪ NoaK plant's O&M contact must consider long-term service agreement (LTSA) ▪ NoaK plant contracts and agreements must be "bankable" with provisions for back-to-back arrangements to mitigate counterparty risks and downside risks
Likely project financing norms	Not applicable	NPV (subject to prevailing interest rates), RROE of 8-10 percent, IRR of 10-12 percent, DSCR of 1.5 to 2.0, Payback period of 5-10 years	▪ Project financing norms based on financial proforma analysis over NoaK plant economic life and subject to sponsors and lenders criteria ▪ Project financing norms subject to conducting a sensitivity and scenario analysis with respect to schedule delays, cost overruns, changes in interest rates with impact on IRR, RROE, DSCR, and payback period

For the pilot project for DICE CRCC, key technology investing stages and funding gaps cover basic R&D, applied R&D, and demonstration activities

The traditional funding and investment stages of progression of energy technology and and investments, including funding sources, development processes and activities:



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Any technology investing and funding gaps must be avoided for pilot project as well as pre-commercialization stages in order for success of DICE CRCC

It is important to overcome any potential funding gaps which may arise for the pilot project during the applied R&D phase and post-demonstration phase (prior to advanced Commercialization*).

Pilot Plant

Next-of-a-kind Commercial Operation Plant

Process	Technology Research		Technology Development	Manufacturing	Commercialization (roll-out/project finance)
Activity	Basic R&D	Applied R&D	Demonstration	Market Development	Commercial Diffusion
Funding Resource	Govt. Grants	Technology Valley of Death	Venture Capital	*Commercialization Valley of Death	Private Equity

Grants and Equity (venture/risk capital)

Equity and Debt

Risk profile is reduced

* "Debt-Equity Gap" as capital requirements for commercializing energy technologies is beyond the risk tolerance and timelines of most existing debt and equity markets.

Definitive O&M experience feedback from DICE CRCC pilot plant can identify, quantify, and mitigate risks for implementing NoAK commercial plant

Modify, Upgrade, Retrofit, Revamp, and Repair

DICE CRCC
Pilot Plant

- Design and fund
- Build and resolve open punch list items
- Commissioning
- Operate and maintain (O&M)

O&M Experience Feedback

- Lessons learned via O&M
- Verify, validate, and certify:
  - Design, performance, and emissions
  - Asset integrity management
  - HSE, OSHA etc.
  - Compliance to standards
  - Finalize "as built" design, performance, emissions, Capex, Opex, LCOE, and other cost metrics

Technical and commercial risk profile identified quantified, reduced, and mitigated

DICE CRCC
NoaK Commercial Plant

Project Sponsors

- Ensure all O&M experience and feedback incorporated during project development
- During feasibility and permitting phase, emphasis on "bankability" of design, performance, emissions, and cost metrics

Project Lenders

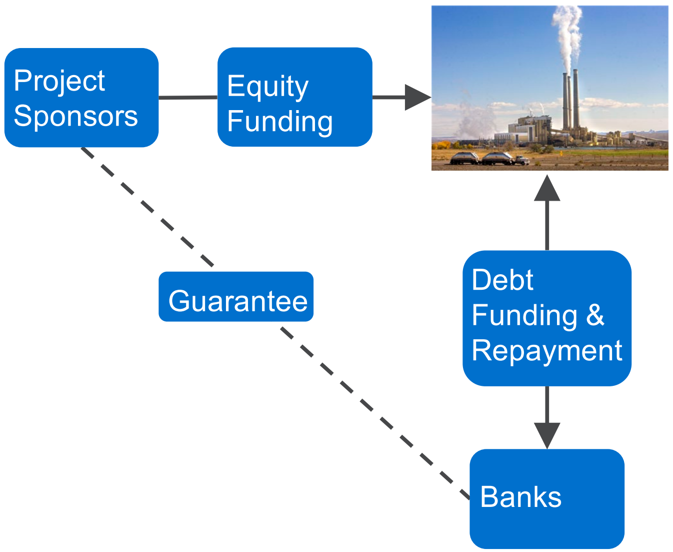
- Conduct detailed technical and commercial due diligence – emphasis on "bankability"
- Emphasis on technical and commercial risks and mitigation analysis – focus on Project counter-party and downside risks along with EPC and O&M "wraps" and insurance

Others in Project

- Al other stakeholders focus on TRL 9 for all components while ensuring reliability, availability, and maintainability (RAM) of all equipment, and systems
- OEMs, EPC, and O&M contractors incorporate all design, performance, emissions, and cost metrics as part of specifications and contracts

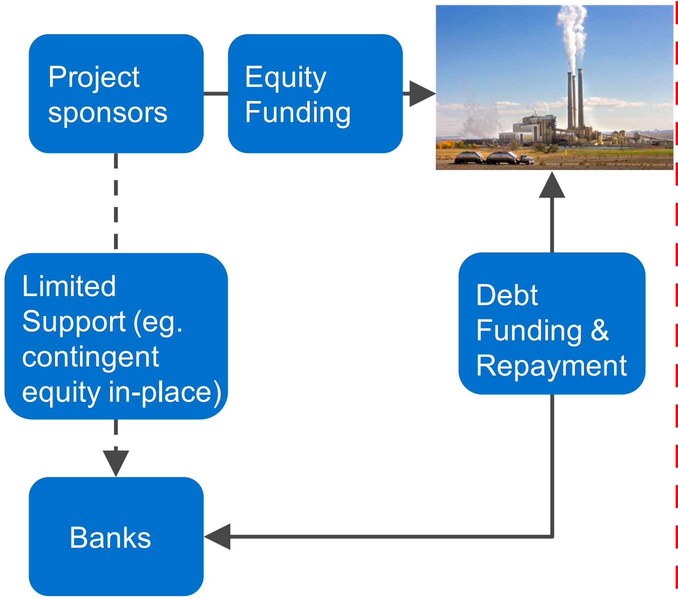
Next-of-a-kind (NoaK) commercial modular plant for DICE CRCC would most likely attract limited recourse financing initially for the first 1 to 3 plants

Full-Recourse Financing



- Repayment of loan fully guaranteed project sponsors (total balance sheet exposure)

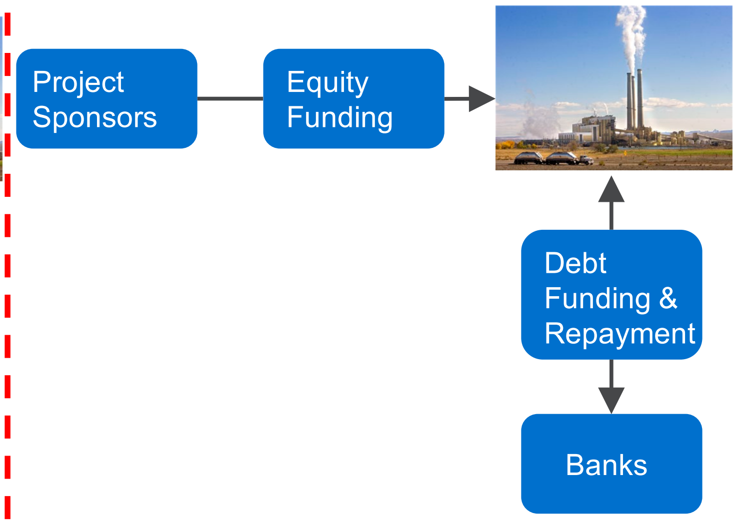
Limited Recourse Financing



- Repayment of loans directly related to the success of the project, with limited support from the project sponsors

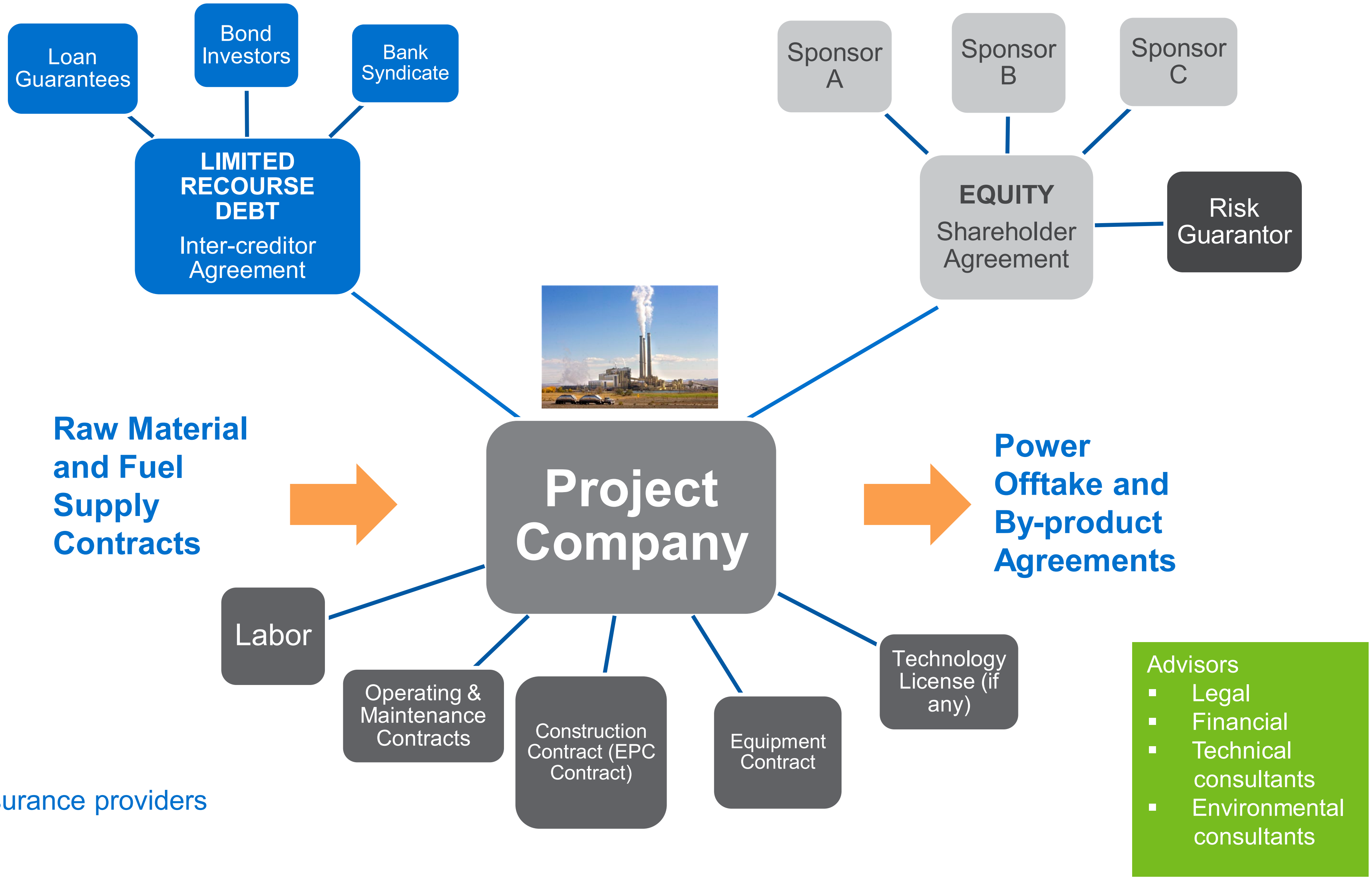
Most Likely

Non-Recourse Financing



- Repayment of loans solely dependent on the success of the project

Project financing structure consists of key stakeholders* covering debt, equity, risk guarantors, EPC and O&M contractors along with bankable contracts



*includes insurance providers

Financing norms include three main phases for NoaK DICE CRCC plant which cover pre-, during, and post-financing stages including financial closure

Pre Financing Stage

- Project identification
- Risk identification, minimization, and mitigation
- Technical and financial feasibility

Financing Stage

- Equity arrangement
- Negotiation and syndication
- Commitments and documentation
- Disbursement

Post Financing Stage

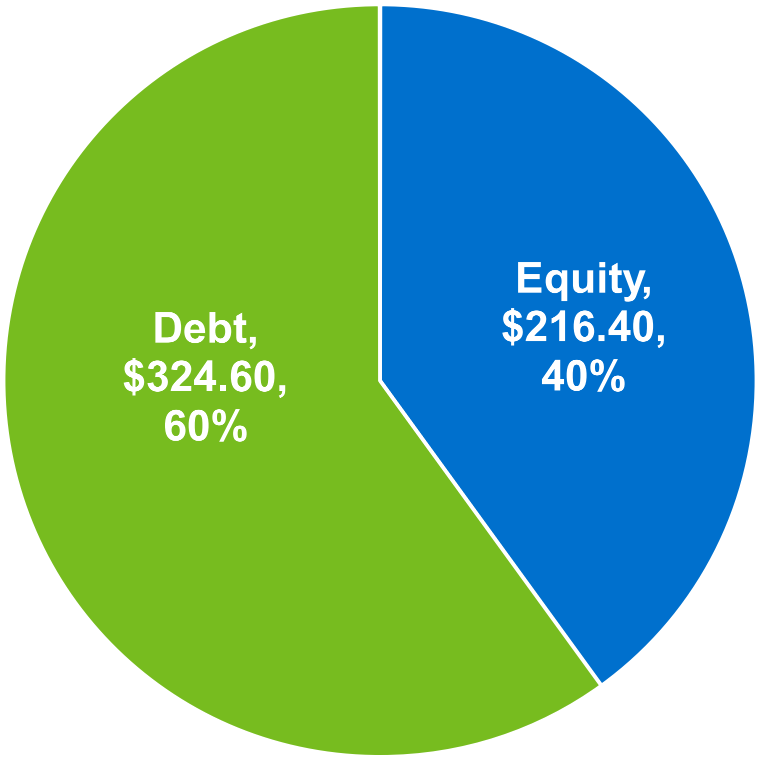
- Monitoring and review
- Financial closure / project closure
- Repayments & subsequent monitoring

Structuring of project financing for DICE CRCC's NoaK plant with total overnight cost of $541 million is based on a Debt : Equity Ratio of 60:40 or 1.5:1

An example of structuring of the project financing is provided based on the Cost Report dated February 15, 2020,. Key assumptions are:

- DICE GT-RCCC Project Capacity: 77 MW
- Total Overnight Cost (TOC): $541 million
- Debt : Equity Ratio: 60 : 40 or 1.5 : 1
- Debt: $324.60 Million
  - Senior and subordinate debt
  - Sources: US Government loan guarantee and lenders (financial institutions, investment banks, and commercial banks)
- Equity: $216.40 Million
  - Common and preferred stock
  - Sources: Project sponsors, developers, private equity (PE) firms, OEMs, EPC and O&M contractors
- Grants: Non assumed since this is not at pilot stage

$ million and percentage



The three stages of project financing for pilot plant and NoaK plant must identify, minimize, and mitigate project risks, external risks, and financing risks

Project financing risks can be divided into 3 key categories which must be considered in order to meet Lender's comfort for the syndication of entire debt for the project:

Project Risks

- Site Selection
- Permitting
- Construction and Completion
- Cost Overruns
- Technology
- Operating
- Sponsor/Developer

External Risks

- Environmental
- Infrastructure
- Political and Regulatory Framework, Policy, and Directives
- Inflation
- Demand and Market

Financing Risks

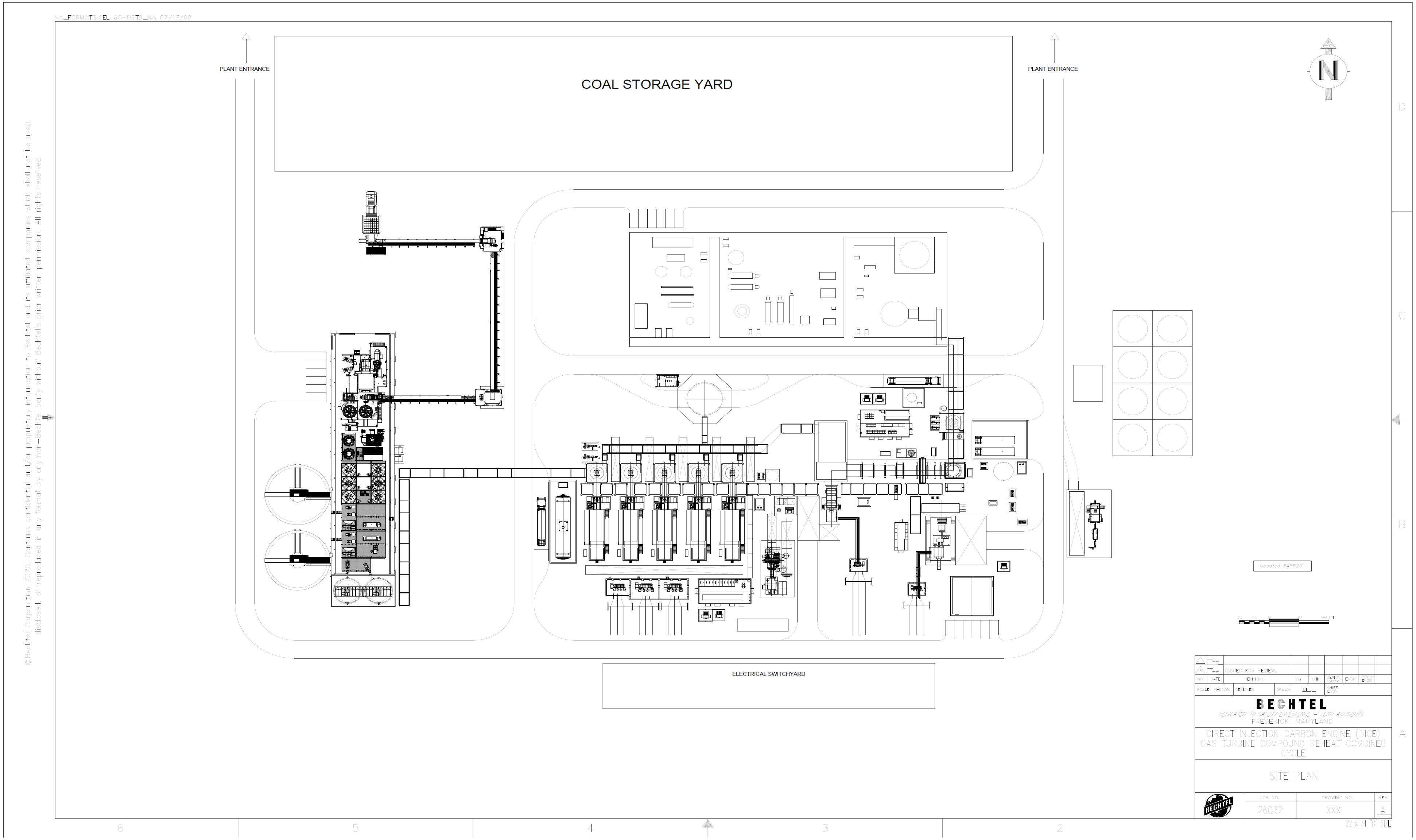
- Floating Interest Rates (currently very low)
- FX Rate on imported technology and equipment

4. Site Selection

DICE plant description consists of 4 main processing blocks – coal beneficiation, power block, post combustion capture, and utilities and off-sites

- DICE plant will consist of the following processing blocks:
  - Coal Beneficiation Plant
  - Power Block
  - Post Combustion Capture (PCC) Block
  - Utilities and Off-sites
- The coal beneficiation plant receives coal from the mine and processes it into a refined, micronized coal-water slurry which is transported to the DICE engines
- The power block consists of the DICE generators, gas expander generator, Heat Recovery Steam Generator (HRSG), steam turbine generator and direct contact cooler
- The cooled exhaust gas is ducted to the PCC unit which produces supercritical carbon dioxide at a pressure of ~2,250 psig for routing to the end user via pipeline
- A waste slurry stream is produced by the coal beneficiation plant which is disposed off-site

DICE CRCC layout is modular in design, highly integrated with key systems, sub-systems, equipment, components, and auxiliaries



Key site selection criteria is based on process requirements - availability of land, CO_2 storage, access to water, logistics, power interconnection, and others

- Key criteria for site selection are driven by the process requirements including:
  - Availability of adequate land suitable for proposed facilities
  - Access to sufficient volumes of water for cooling tower makeup
  - Proximity to carbon dioxide storage location or end user, alternatively proximity to an existing carbon dioxide pipeline which has spare capacity to transport the produced carbon dioxide
  - Proximity to rail or ocean/river ports for transport of coal or proximity to an existing coal fired plant which is willing to allow sharing of unit coal trains or ocean/river ports for transport of heavy equipment
  - Distance from power grid for inter-connection
  - Site should not be located in a non-attainment area for air pollution standards
  - Proximity to rail

These criteria are elaborated in the following slides.

Availability of suitable land is dependent upon specific pre-requisites, design criteria which will enable proper development, execution, and operations

- Availability of suitable land
  - Land should be reasonably flat and not prone to landslides
  - Land should not be located in 100 year floodplain or on wetlands
  - The land should not be in a high seismic zone prone to frequent earthquakes
  - Proposed site should have satisfactory geological and hydrological characteristics
  - The proposed site should not be located in areas of historical, religious or cultural importance
  - The proposed site should not be too close to urban areas or areas where population may grow rapidly
  - The proposed site should not be in proximity to existing hazardous areas or facilities
  - The proposed site should allow disposal of waste streams from the facility (coal beneficiation waste tailings, fly-ash, process wastes, waste water, etc.)
  - In the event that limited supply of makeup water is available, account for additional land for installing **Air Cooled Condensers (ACC)** and **Zero Liquid Discharge (ZLD) systems**

Availability of adequate water with proper quality, sufficient volumes, proximity, backup sources, and proper discharge are key to project development

- Access to adequate water
  - Availability of water supply of reasonable quality and sufficient volume for cooling tower and cooling water makeup, coal slurry preparation, and other consumptive uses
  - Source of water should not be too distant from the potential site and the route should not entail significant physical or legal obstacles
  - Allowance should be made for backup/emergency source of water
  - Site should have provision for discharge of waste water streams
  - In the event that limited supply of makeup water is available, consider optional use ACC and ZLD systems

Carbon dioxide, heavy equipment, and coal transport must be addressed as part of project execution plan focusing on proximity, easy access, and transport

- Proximity to carbon dioxide storage location or end user
  - Site should not be too distant from where the carbon dioxide will be used or stored, or near an existing carbon dioxide pipeline that can take the additional carbon dioxide produced by the facility.
  - Pipe route should not present significant physical or legal obstacles
  - If the gas is to be stored in a saline reservoir, conditions in the reservoir need to be considered during site selection
- Proximity to rail or ocean/river ports for transport of heavy equipment, coal, etc.
  - Proposed site should allow for transport of heavy and large pieces of equipment by river and/or ocean freight
  - Adequate facilities should be available to trans-ship equipment by rail and/or truck, as required
  - Proposed site should have rail or road access for transporting coal from the mine and should be located a reasonable distance from the mine

Distance from nearest power grid is key for interconnection and evacuation, and site should address non-attainment areas for air pollution standards

- Distance from power grid for inter-connection
  - Proposed site should be within a reasonable distance from the power grid for evacuation of power
  - The transmission line route should not present significant physical, technical or legal obstacles
- Site should not be located in a non-attainment area for air pollution standards
  - Proposed site should not be located in areas designated as non-attainment for pollutants

Unique requirements for selection of first DICE plant cover preferable location in US Gulf Coast, proximity to PRB coal and CO_2 storage, and other key areas

- Preferable location shall:
  - Be close to the **US Gulf Coast** for ease of transportation of large modules and equipment, including trans-shipment via barge
  - Be close to an existing coal fired plant that uses PRB coal
  - Locate near an end user/storage location for the produced carbon dioxide or to an existing carbon dioxide pipeline with enough spare capacity to handle the additional output from the DICE plant
  - Provide potential users who can receive the tailings from the coal beneficiation plant and use them productively
- **US Gulf Coast** as DICE CRCC plant location of choice:
  - The US Gulf coast has several power plants that use or used PRB coal and get regular shipments from the mines by rail and/or barge. The Big Cajun power plant located in Louisiana is one example of such a facility.
  - In addition, there is an existing carbon dioxide pipeline (Denbury pipeline) located not too far from the Big Cajun power plant that transports CO_2 to customers and points of use that could potentially be used for transporting the carbon dioxide capture in the DICE plant
  - With regards to the use of the tailings from the coal beneficiation process, the potential use will need to be explored and users will need to be developed as part of the next phase of the Project

5. Partnering with Technology Providers

Coal Beneficiation Plant

- Sedgman is able to perform design, supply, fabrication, delivery, construction and commissioning of the coal beneficiation plant
- Technologies of note that require further test work and validation
  - Flotation cells: Sedgman C-Cells
  - Fine Grinding Mill: FLSmidth (VXPMill); Outotec (HIG Mill); Glencore Technology (IsaMill)
- For CoalFIRST Critical Component development, plan to partner with Virginia Tech (Prof Roe-Hoan Yoon) to develop and test beneficiation process on variety of coals, including PRB, Eastern coals, and coal fines
  - Convert low-rank PRB coal from hydrophilic to hydrophobic
  - Electrochemical treatment to remove mineral matter
  - Convert mineral matter to fertilizer

DICE

- Reaching out to major engine OEMs (Wartsila, MAN) did not bear fruit
  - *"Coal slurry is a cheap fuel that is locally available in the world. There are investigations, in accordance with MAN ES' own experience on that matter, showing that this fuel is very abrasive. First tests on our engines and evaluations from our experts have shown, that it causes high war in the engine and its subsystems like the Fuel Injection Equipment. Additionally it has to be ignited by an additional pilot fuel (e.g. DMA) by using a high pressure injection system. This would result in a new engine and fuel injection equipment concept, with significant efforts for MAN Energy Solutions to handle this fuel. The current strategy of MAN Energy Solutions does not foresee a development in this direction"*
  - *[Wartsila has] a record of developing recip engines to burn some pretty challenging fuels, such as Orimulsion. But aligning ourselves to explore coal combustion is at odds with our corporate identity of supporting carbon reduction and high renewable systems…[Wartsila is] currently investing in alternative fuel R&D, but more aligned with renewable and carbon-neutral, which fit into a "net zero" paradigm"*
- "Piggyback" on existing work by CSIRO
  - CSIRO has a long history in DICE development
  - Currently working with Yancoal and Chinese engine developer (Zichai)
  - Progress is delayed by the COVID-19 crisis
- For CoalFIRST Critical Component development, plan to partner with CSIRO to further develop DICE fuel injector and cylinders and conduct series of tests for coal-fired engines

Recent CSIRO work on DICE

- A recent study with the Australian Coal Industry and MAN involving a MAN-LGI system modified for MRC by the CSIRO. Tests involved passing nearly 50 tonnes of MRC through the 600 bar injector on a spray bench. Terminated due to disagreements between MAN and the coal industry on engine development, the coal industry's concern over the potential competition with supercritical PC with PCC, and MAN's focus on next-generation engines for ammonia and hydrogen fuels.
- A recent study with Maersk and WING&D on the use of MRC for deepwater marine. CSIRO designed the injectors and fuel system for a 10 MW 4-cylinder engine which was successfully trialed in Switzerland showing excellent combustion results. Terminated due to the IMO's new regulations on the decarbonization of shipping by 2050.
- Use of biomass in DICE to halve the cost and double the benefit of biomass for electricity generation. Includes triple bottom line studies using saltbush (animal feed, fuel and soil carbon).
- Production of high quality MRC fuel from a wide range of coals - Australian (bituminous, sub-bituminous, brown), German, Indonesian (hydrothermally treated), and Venezuelan.

6. Permitting

Permitting for DICE requires prompt action from site selection, emissions estimates, meeting state requirements and timelines, and pre-/post-approval

- The permitting process should be initiated as soon as a site has been selected for the DICE power plant and the scale of the plant is established
- Initial estimates of plant capacity and emissions of regulated pollutants (based on manufacturers data) should be tested against applicable thresholds to determine application requirements
- Permit requirements vary by state and within states as well based on whether an area is classified as attainment or non-attainment
- For planning purposes it may be prudent to allow 12 to 18 months for obtaining the air permit
- Most states have specific guidelines and instructions for preparation of the air permit application
- In general the types of documents required to be submitted with the application include site plans and facility design documents in sufficient detail to establish location, scale, and relationships, horizontally and vertically, to and between adjacent properties

Permitting must address physical locations, equipment emissions, plant load data, air quality impact, EPA's NSR program, and other specific documentation

- Stack and building heights and locations are established in these documents
- Equipment manufacturer's emissions data are required. This information may be representative as actual equipment sources may not be known at this stage of the project
- Estimated plant load data – both peak and annual – should be calculated
- Determine potential emissions by applying the above factors and assuming that all new capacity operates at full rated load for 24 hours per day, 365 days per year
- **Air Quality Impact Assessment** may be required depending on the scale of the project
- The EPA's **New Source Review (NSR)** permitting program will apply, it's goal is to maintain air quality when major new sources of emissions are built
- NSR requirements may fall under one of the following categories:
  - **Prevention of Significant Deterioration (PSD)** permits are required for new sources in areas which meet the **National Ambient Air Quality Standards (NAAQS)**
  - Nonattainment NSR permits are required for major new sources in areas that do not meet NAAQS

DICE permitting must include BACT, LAER, SIPs, regulated GHG emissions, Title V, onsite record keeping, and key certification of compliance requirements

- Under the PSD permit new plants are required to include **Best Available Control Technology (BACT)**
- Non attainment areas require application of **Lowest Achievable Emission Rate (LAER)** technology, in addition to emission offsets and public involvement
- **State Implementation Plans (SIP's)**: Most states have developed SIP's under a mandate by the EPA to issue air permits, while the EPA maintains general oversight
- Regulated emissions include NOx, SOx, mercury, VOCs and particulate matter, among others
- When the plant reaches the operational phase a **Title V** permit is required as a means to provide a database for monitoring and enforcement
- Title V applications require as a minimum, a means of reporting air emissions either by CEMS or other means
- Onsite record keeping of relevant data
- Certification of compliance with applicable emission limitations

Indicative list of permits required cover a wide range of federal, state, and local requirements including US Army Corps of Engineers, and other documentation

- Indicative list of other permits required for power plant projects include wetlands permit, water withdrawal permit, waste water discharge permit, natural heritage program permit, certificate of public convenience and necessity, traffic plan consultations and agreements, parks and recreation historic preservation, storm water control permits, no hazard to aviation permit, threatened and endangered species consultation, local jurisdiction permits, **US Army Corps of Engineers** permits, state permits, noise permit, and others as applicable
- An environmental commitments matrix is developed during the project phase to track regulatory based design requirements. That document should tabulate the requirements from the various permits as well as action items, action owner and status
- In addition to the permits described above, there may be others required for construction of power plants that are issued by local and state agencies. Those permits would need to be obtained before start of construction

7. Detailed Design of Project Concept

Detailed design of project concept of process/power units requires proper planning, execution, and coordination with OEMs and lead EPC contractor

- Correct execution of the detailed design phase of the project is critical to ensure project success
- The detailed design of the plant will entail engineering of the following process/power units, carried out by different entities and coordinated by the lead EPC contractor:
  - Coal beneficiation plant
  - DICE CRCC power plant including as expander generator, heat recovery steam generator and steam turbine generator
  - Carbon capture and compression plant
- The detailed design of the plant will entail engineering of the following process/power units, carried out by different entities and coordinated by the lead EPC contractor:
  - Execution strategy, plan and schedule
  - Focus areas based on the overall project schedule
  - Delineation of work performed by various groups during the detailed design phase
  - Staffing forecasts and implementation
  - Major engineering risks and mitigation
  - Detailed design execution budget and performance

Each of the above tasks is discussed in detail in the following slides.

Detailed design execution strategy must be goal driven covering scope and schedule, coordination, 3D models, risk management, and schedule tracking

- Detailed Design Execution strategy has the following goals:
  - The contract will determine the scope and schedule of detailed design engineering
  - Detailed design will be performed in accordance with the contract
  - Develop quality engineering design that minimizes re-work
  - Coordinate detailed design with construction, startup, and overall project schedules for optimizing overall project duration
  - Ensure physical design coordination by developing a 3D model to eliminate interferences and ensure operability and access for maintenance
  - Manage risks associated with detailed design development
  - Control design interfaces with equipment suppliers and sub-contractors
  - Implement a management of change process
  - Engage, challenge and grow engineer’s skill in the detailed design process
  - Track key metrics to ensure quality, budget, cost and safety compliance
  - Detailed design to account for sustainability and energy efficiency

Overall project schedule must address task sequencing, impacts, procurement, construction, coordination interfaces, staffing, and design of physical plant

- Focus areas based on the overall project schedule
  - Engineering provides input to Project schedule accounting for construction sequencing, weather related impacts and project turnover and completion dates
  - Project procurement, construction and startup schedules shall drive detailed design execution
  - Develop detailed design plans to cover major systems and equipment
  - Coordinate design interfaces with vendors and sub-contractors to ensure a functional and efficient power plant
  - Identify and manage critical interfaces between the power and coal beneficiation and carbon capture blocks, and coordinate with the entities responsible for their detailed design
  - Develop staffing plans based on project schedule
  - Initial design activities are geared to design of earthworks, foundations and underground structures, underground piping and ducts, grounding and storm water systems

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Design phase must cover work execution by groups, coordination, implement design guidelines, staffing forecasts, deliverables, and critical-path milestones

- Delineation of work performed by various groups during the detailed design phase
  - Coordinate schedule and interfaces between the entities designing the coal beneficiation, power plant and carbon capture blocks
  - Develop and implement design guidelines and engineering procedures
  - Set up a design organization that will carry out detailed design and interface with vendors and contractors who will be responsible for certain aspects of the design
  - Identify electronic tools to be used for detailed design for all aspects and disciplines
- Staffing forecasts and implementation
  - Develop organization chart and staffing levels for all teams working on the three blocks of the project
  - Establish division of responsibilities for the detailed design teams
  - Each team will have their own teams and deliverables that support the overall project schedule
  - The lead EPC contractor will be responsible for overall schedule and internal coordination
  - Initiate regular meetings to track status and resolve issues that may impact design progress

Major risks must be identified and mitigated measures implemented along with focus on project execution, budgets, regular tracking, and performance metrics

- Major engineering risks and mitigation
  - Develop a detailed design risk register at the beginning of the project to identify risks and potential strategies for their mitigation
  - Risks to include those related to all parts of the project including coal beneficiation, power block and carbon capture and compression units
  - Risks can be associated with first-of-a-kind equipment, integrated functionality and control, and performance guarantees
  - Include risks associated with unique manufacturers supplying specialized equipment
- Detailed design execution budget and performance
  - Set up detailed design budgets, deliverables and schedule for design deliverables for each discipline for each of three entities designing the coal beneficiation plant, power plant, and carbon capture plant
  - Track progress by each discipline to ensure project stays on track for timely completion
  - Establish plans to mitigate and minimize schedule slippage by adding resources as appropriate, in a timely manner
  - Ensure motivation of the design team by holding team building activities and providing incentives for innovative design and execution that improves quality and reduces cost