REINHOLD ENVIRONMENTAL ®

2025 Reinhold/PCUG Round Table Presentation

Hosted by AEP and Buckeye Power

in The Hilton Columbus Polaris Hotel, Columbus, OH

on June 23-24, 2025

2025 REINHOLD/PCUG CONFERENCE

Hosted by AEP and Buckeye Power

FEL PROCESS FOR PROJECT EXECUTION

Michael Varner – Merrick & Company

Market Sector Leader, Power

June 24, 2025

WHO IS MERRICK?

Merrick is an employee-owned engineering company providing full-service engineering & consulting services to the power industry.

ABOUT **MERRICK**

OUR **PURPOSE**

SOLVING.
GROWING.
LIVING.

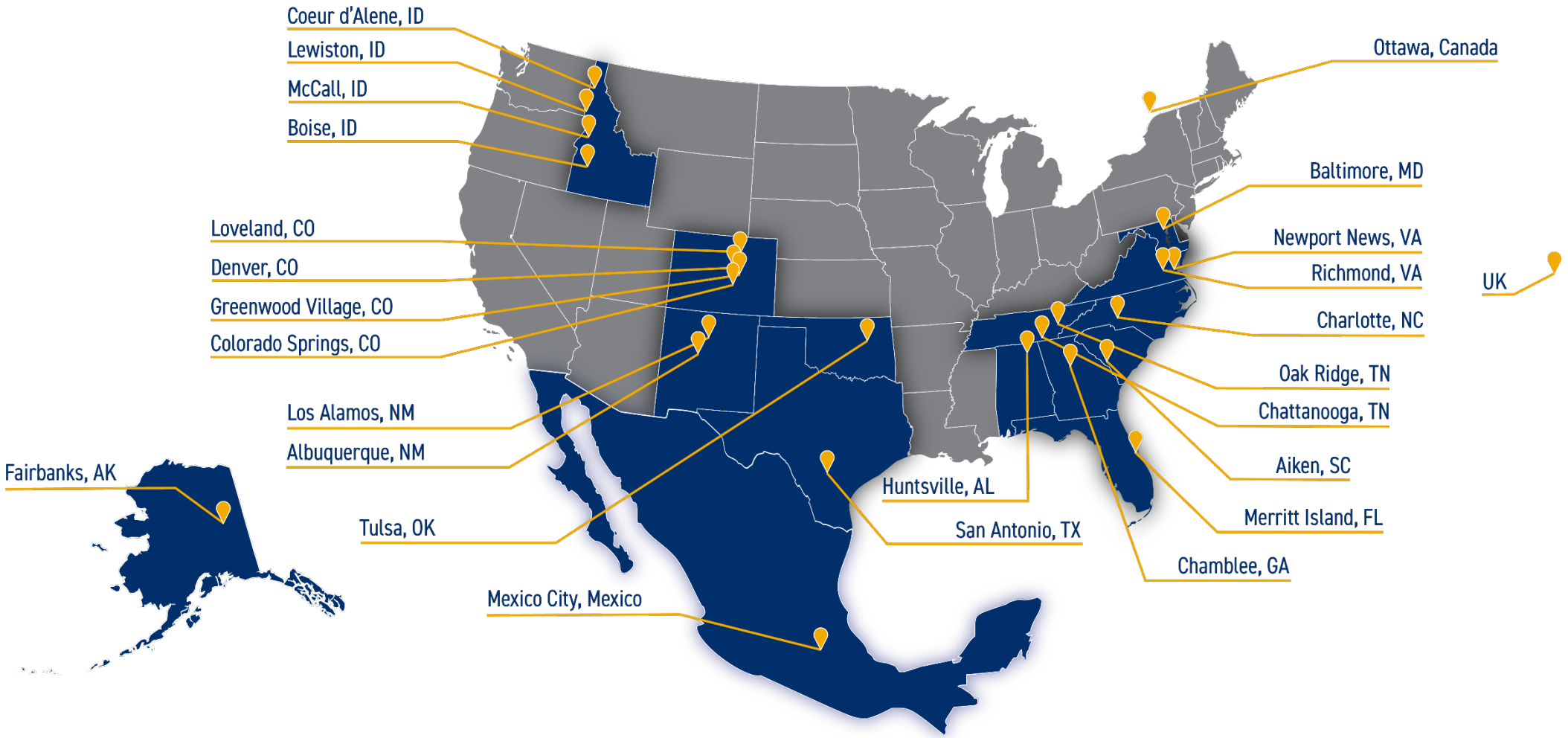
OUR **VISION**

Our family of employee owners collaboratively developing the right solutions to better our world.

FAST **FACTS**

1. **R**ESPECT**, I**NTEGRITY, **S**ERVICE & **E**XCELLENCE. We live our core values every day in how we work together, stay true to our purpose, and pursue our vision.
2. Founded in 1955 by Sears Merrick and Ed Lecuyer
3. Employee-owned with more than 1000 employees
4. Full-service, multi-disciplinary engineering and architecture firm headquartered in Colorado
5. 26 office locations (23 in the U.S., 1 in Canada, 1 in Mexico, 1 in the U.K.)

26 OFFICE
LOCATIONS



MINIMIZING DISRUPTION TO YOUR OPERATION WHILE ENSURING SMOOTH PROJECT DELIVERY

With critical capabilities in-house, we streamline your project **from conception to completion.**

Facility Retrofits

- Energy Storage
- Fossil Plants
- Gas Fired
- Hydroelectric
- Renewables
- Waste to Energy

Professional Services

- Conceptual Designs
- Feasibility Studies
- Detailed Engineering
- Cost Estimating
- Project Integration
- Project Management

TOPIC OF DISCUSSION

FEL APPROACH TO PROJECT EXECUTION

WHAT'S THE SOLUTION

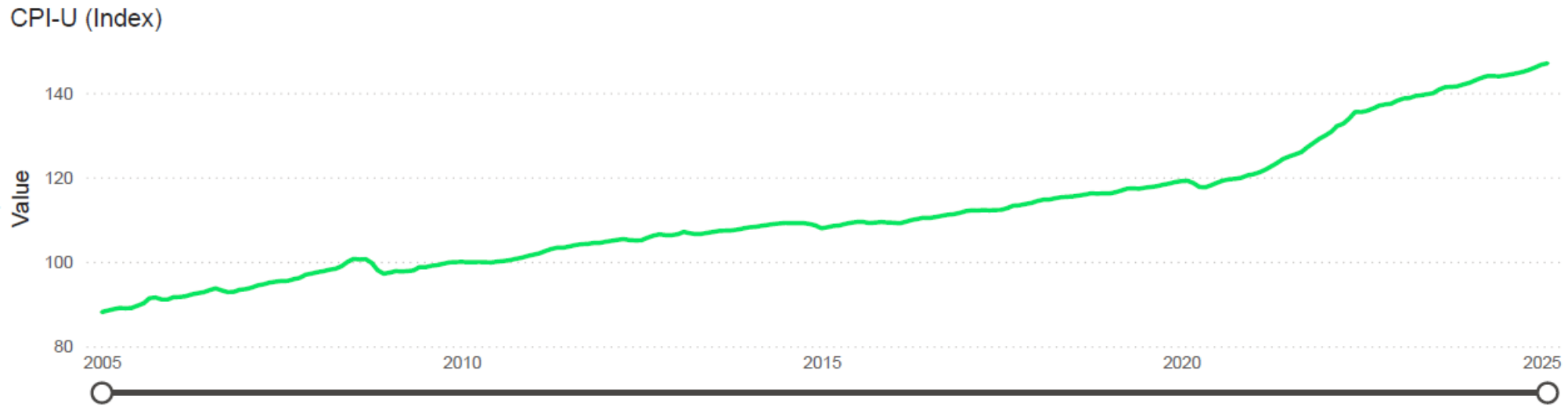
1. Use an FEL approach for project execution. Also called a stage gate approach.

AND

2. Get your engineering and construction partners involved early in the project.

CONSUMER PRICE / EMPLOYMENT TRENDS

CPI
CPI-U
CPI-U, Less Food and Energy
GDP
Labor Force Participation Rate



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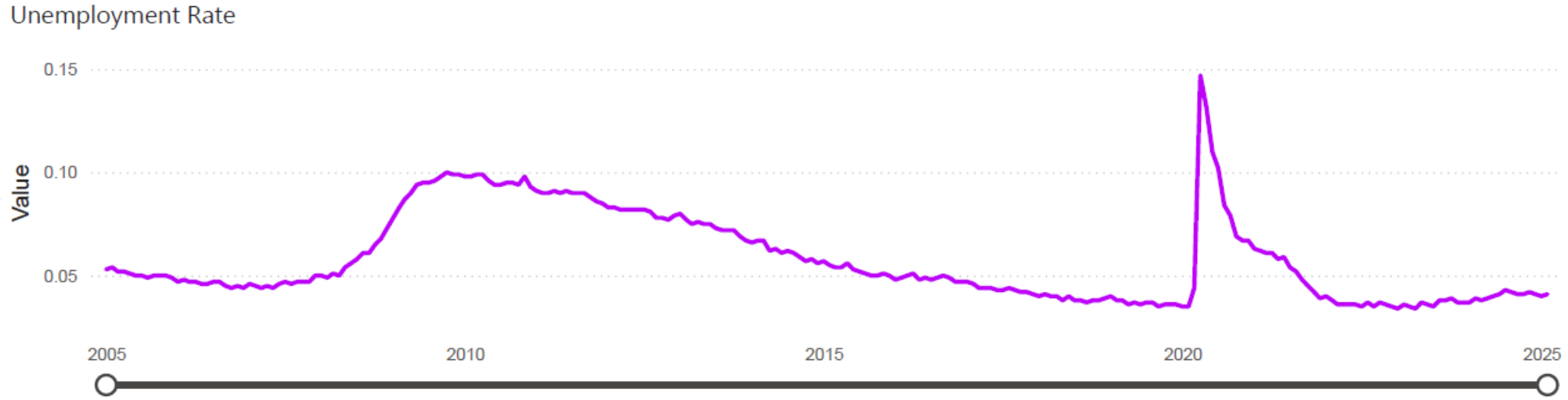
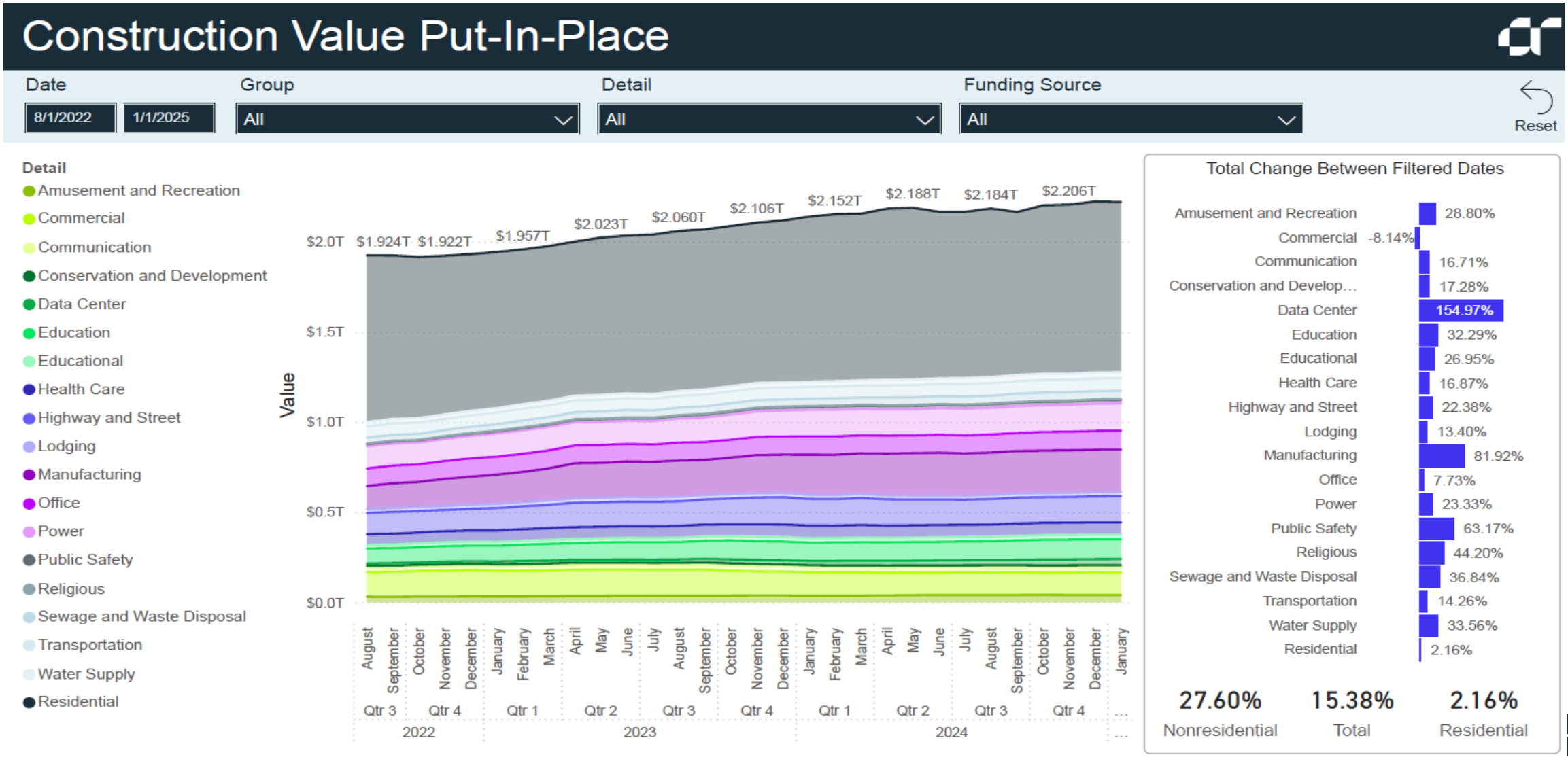


Source: U.S. Bureau of Labor Statistic

CONSTRUCTION PRICING TREND



Source: U.S. Bureau of Labor Statistic

EQUIPMENT LEAD TIMES

Equipment / Material	Historical Lead Time (Weeks)	Current Lead Time (weeks)
Low Voltage Switchgear	10-30	40-50
Medium Voltage Switchgear	20-40	45-60
Air Cooled Chillers < 250 Tons	5-8	20-23
Air Cooled Chillers > 250 Tons	9-12	30-33
Electrical Enclosures	40	80
HV Breakers	10-40	100
Diesel Generators <1 MW	2-6	22
Diesel Generators > 1MW	4-8	60
Cooling Tower	4-6	14-16
UPS – Uninterruptible Power Supply	20-30	30-40
Medium Voltage Transformers (<5MVA)	20-40	50-60
Medium Voltage Transformers (5-100MVA)	40-60	70-104
Medium Voltage Transformers (>100MVA)	40-60	170-220

WHAT'S THE SOLUTION

FEL approach for project execution.

DEFINITION

What is FEL, or Front-End Loading?

A structured project management process used early in a project's lifecycle to define the project scope, feasibility, and costs before detailed design and construction begin.

DEFINITION

What is the FEL process?

1. A phased approach to project execution.
2. Focused on comprehensive planning and design in the early stages of a project.
3. Each stage culminates in a decision point to proceed, revise, or cancel the project based on thorough analysis and risk assessment.
4. The primary goal of FEL is to reduce risks, optimize resource allocation, and improve the overall success of a project by making informed decisions early on.

TERMINOLOGY

- FEL – Front End Loading
- FEP – Front End Planning
- FEED – Front End Engineering Design
- PPP – Pre-Project Planning

All of them are similar, but each has its own vocabulary and acronyms. What's common is they all use a **stage gate approach**.

We will use FEL as a "catch all".

FOUNDATION OF FEL

- FEL transforms a business need or opportunity into a detailed production design basis
- FEL provides a common framework for all project development activities, including basis of design, schedule, cost and technical details
- FEL precedes detailed multi-disciplined engineering
- FEL is widely accepted as a process industry “best practice” although many variations exists

FEL answers the following questions:
Why? What? When? How? Where? Who?

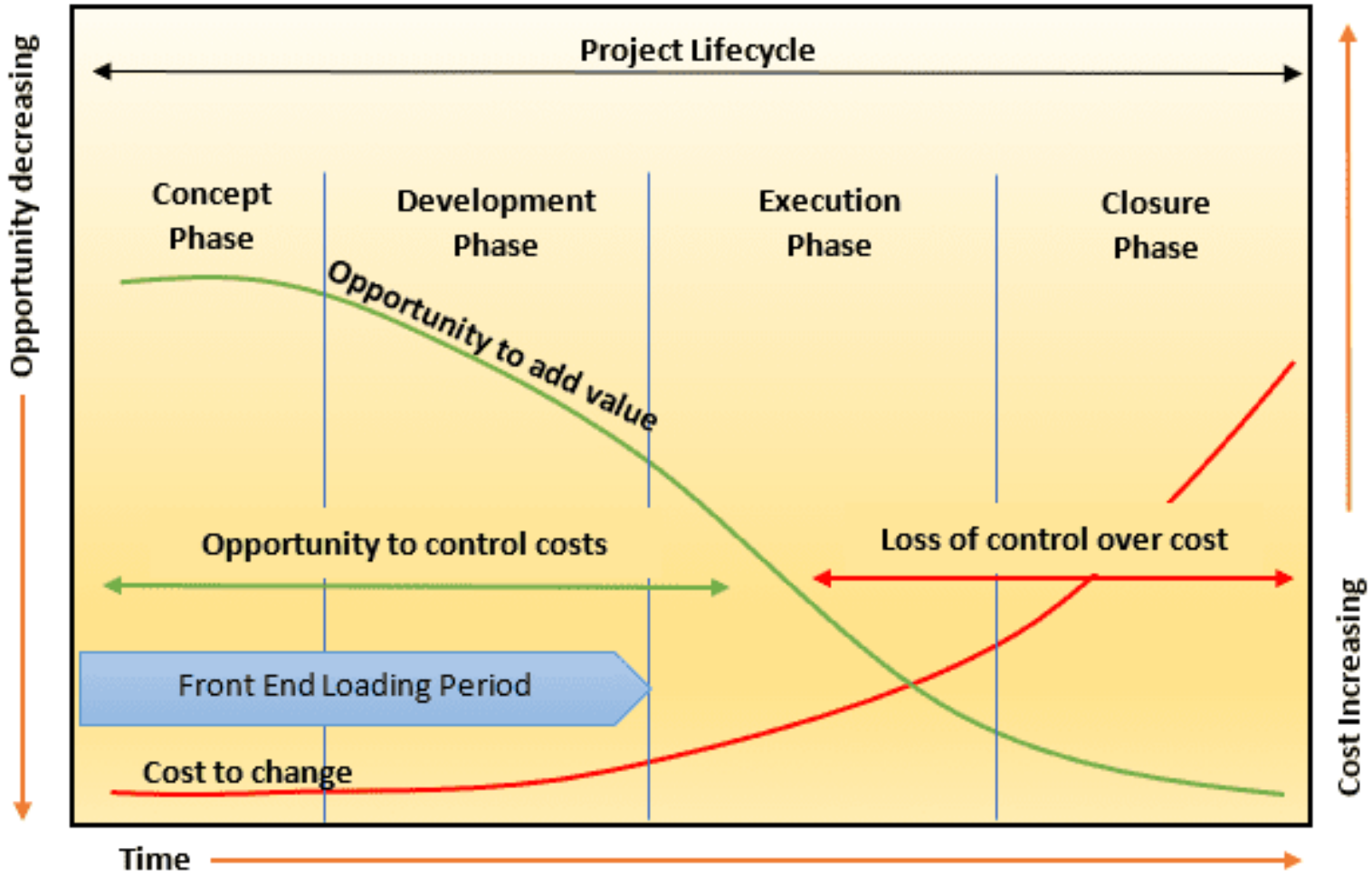
FOUNDATION OF FEL

- The outcome of a project can be greatly influenced at a relatively low cost early in the project
  - Select the best projects; eliminate the poor projects
  - Select the best technology / design approach / solution
  - Select the appropriate scope of work
  - Select the most accurate, optimized execution schedule
- The work completed at the start of a project has a direct effect on the success of the project
  - Better planning drives better results
  - “Best Practices” help drive down cost and improve schedule
  - Encourages “Value Engineering” to optimize the overall project solution

FEL is best managed in 3 distinct stages.

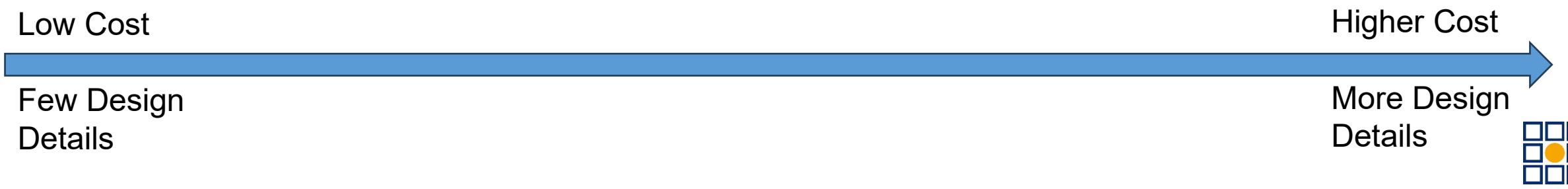
FEL-1 → FEL-2 → FEL-3 → Detailed Design → Construction → Startup

COST BENEFIT CURVE



FEL STAGES

FEL1 Business Plan	FEL2 Conceptual Design	FEL3 Project Definition
Determine if a capital project is needed to meet business need	Evaluate alternatives; develop basis of design	Develop detailed process design and major equipment design
+/- 50% estimate	+/- 30% estimate	+/- 10% estimate
Level I master schedule	Level II milestone schedule	Level III project schedule
0.25% to 0.5% TIC	0.5% to 1.0% TIC	1% to 3% TIC
Project charter	Basis of design	Bid documents
Gate 1 **Project Approved**	**Gate 2** **Design Basis Approved**	**Gate 3** **Approved Project Funding**



FEL1 – BUSINESS PLANNING

- FEL -1 is business planning driven:
  - Clearly define business need/opportunity
  - Identify potential technologies/alternatives
  - Provide first pass at project economics and risk analysis

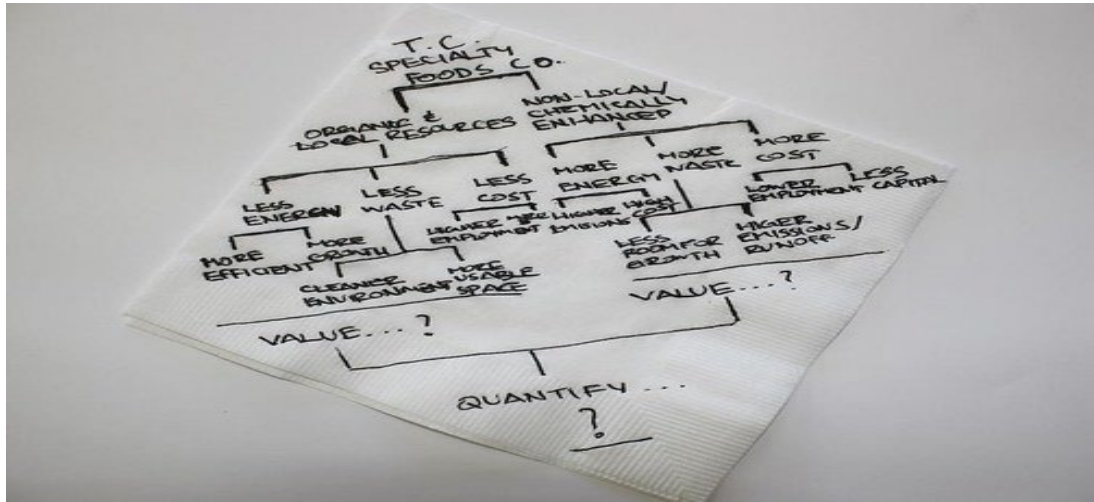
- FEL-1 aligns technical concepts with the business need/opportunity

FEL-1 offers the opportunity to affect the ultimate direction of a project at the lowest cost.

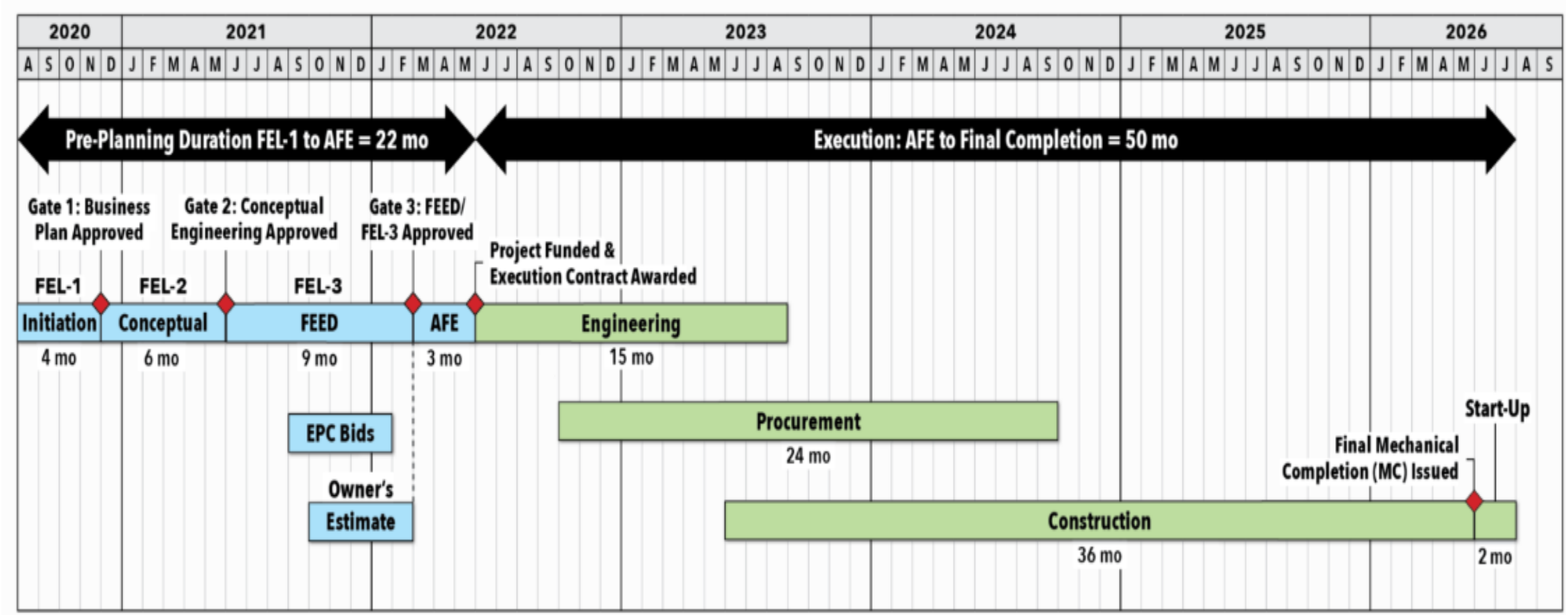
FEL1 DELIVERABLES

- Identify Project Stakeholders
- Project Goals/Objectives (Charter)
- Business Plan Summary
  - Market Forecasts
  - Supply/Demand Forecasts
  - Competitive Studies
  - Product Market Life
  - First Project Pass Economics
- Technology Assessment
- Relevant Project Benchmarking
- Scope of Work Summary

- Block Flow Diagram (PFDs)
- Order of Magnitude Cost Estimate (50%)
- Level I Project Schedule
- Risk Register/Summary
- Plot Plan



EXAMPLE LEVEL I SCHEDULE



FEL2 – CONCEPTUAL DESIGN

FEL-2 advances the project development activities

- Evaluate possible alternatives
- Select best technology and/or process for the overall design
- Complete conceptual engineering package

FEL-2 employs a larger team generally focused on process engineering with strong business and operations input

Core purpose of FEL-2 is to develop and evaluate alternatives from a technical perspective and choose the best alternative.

FEL2 DELIVERABLES

- Site Evaluation
- Refined Scope of Work
- Evaluation and Selection of Best Alternatives w/Decision Matrix
- Project Execution Plan
- Contracting Strategies
- Value Engineering Studies
- Business Pro Forma w/ Cash Flow
- Level II Project Schedule
- Risk Assessment
- Conceptual Cost Estimate (20-30%)

- Conceptual Engineering Package
  - Basis of Design
  - Process Flow Diagrams
  - Utilities and Chemical Summary
  - Mass and Energy Balance
  - Preliminary Process Description
  - Site/Plot Plan
  - Preliminary General Arrangement
  - Engineering Data Sheets for Major Equipment
  - Sized Equipment List
  - Preliminary Electrical One Line/Loads
  - I&C Architecture Overview (I/O Est)
  - Building Definition criteria
  - Foundation Definition list
  - Major Line and Equipment sizing
  - P&ID’s

FEL3 – PROJECT DEFINITION

Involves a larger project team

- Continue development of FEL-2 chosen concept for a single selected option

Refine project cost, schedule and scope to mitigate risks

- Complete enough detail to allow for a “No Change” Production Design
- Long-lead equipment orders often placed w/ cancellation options

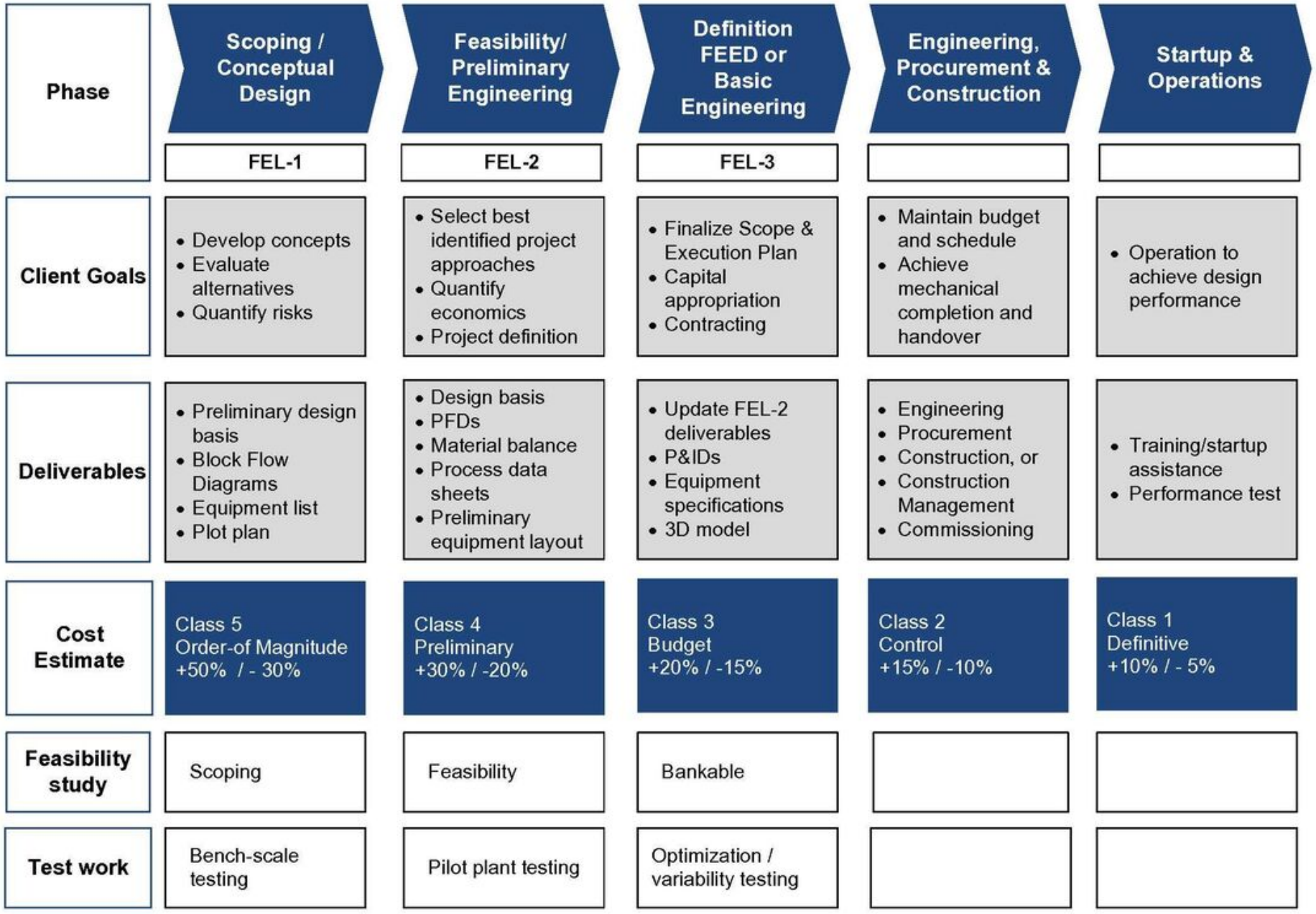
FEL-3 provides the Basis of Design and “starting point” for the remaining detailed engineering package.

FEL3 DELIVERABLES

- Request for Funding/Authorization
- Detailed Scope of Work
- Integrated Project Schedule
- Cost Estimate (+/- 10 to 15%)
- Risk Assessment
- Updated Project Execution Plan
- Procurement Plan
- Order Long Lead Equipment
- Updated Business Pro Forma
- Lessons Learned Summary

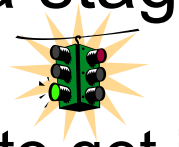
- FEL 3 Design Package
  - Basis of Design for Detailed Design
  - P&ID's
  - Equipment List
  - Site / Plot Plans
  - Equipment Arrangement / 3D Model
  - Line List / Tie-in List
  - Instrument List
  - Piping Specifications
  - Equipment Specifications/Data Sheets
  - Updated Electrical One Lines
  - Electrical Area Classifications
  - ETAP Study
  - I&C Architecture Overview (I/O Count)
  - Major Line and Equipment sizing
  - Electrical Load List
  - Foundation Location Plan

PROJECT EXECUTION PLAN SUMMARY



Phase	Scoping / Conceptual Design	Feasibility/ Preliminary Engineering	Definition FEED or Basic Engineering	Engineering, Procurement & Construction	Startup & Operations
	FEL-1	FEL-2	FEL-3		
Client Goals	• Develop concepts • Evaluate alternatives • Quantify risks	• Select best identified project approaches • Quantify economics • Project definition	• Finalize Scope & Execution Plan • Capital appropriation • Contracting	• Maintain budget and schedule • Achieve mechanical completion and handover	• Operation to achieve design performance
Deliverables	• Preliminary design basis • Block Flow Diagrams • Equipment list • Plot plan	• Design basis • PFDs • Material balance • Process data sheets • Preliminary equipment layout	• Update FEL-2 deliverables • P&IDs • Equipment specifications • 3D model	• Engineering • Procurement • Construction, or • Construction Management • Commissioning	• Training/startup assistance • Performance test
Cost Estimate	Class 5 Order-of Magnitude +50% / - 30%	Class 4 Preliminary +30% / -20%	Class 3 Budget +20% / -15%	Class 2 Control +15% / -10%	Class 1 Definitive +10% / - 5%
Feasibility study	Scoping	Feasibility	Bankable		
Test work	Bench-scale testing	Pilot plant testing	Optimization / variability testing		

STAGE GATE REVIEW

- Select an individual(s) to manage the FEL effort from one stage to the next
- Gate keepers are key decision makers and can include Project Sponsor, Business Manager, or Project Leader
- Three possible outcomes of a stage gate review include:
  - Move on to the next FEL step 
  - Rework the current FEL stage to get it right 
  - Stop the project 

KEY SUCCESS FACTORS

1. Complete all 3 FEL stages…don't skip a step as it will be expensive in the long run
2. Select and empower Gate Keeper(s) to make decisions that will not be second guessed
3. Involve individual design disciplines early in the process
4. Develop and agree on project design basis and goals early
5. Document design assumptions from all engineering disciplines
6. Get early involvement from Operations/Maintenance/Construction
7. Maintain continuity of the project team
8. Actively manage change through a "management of change" process

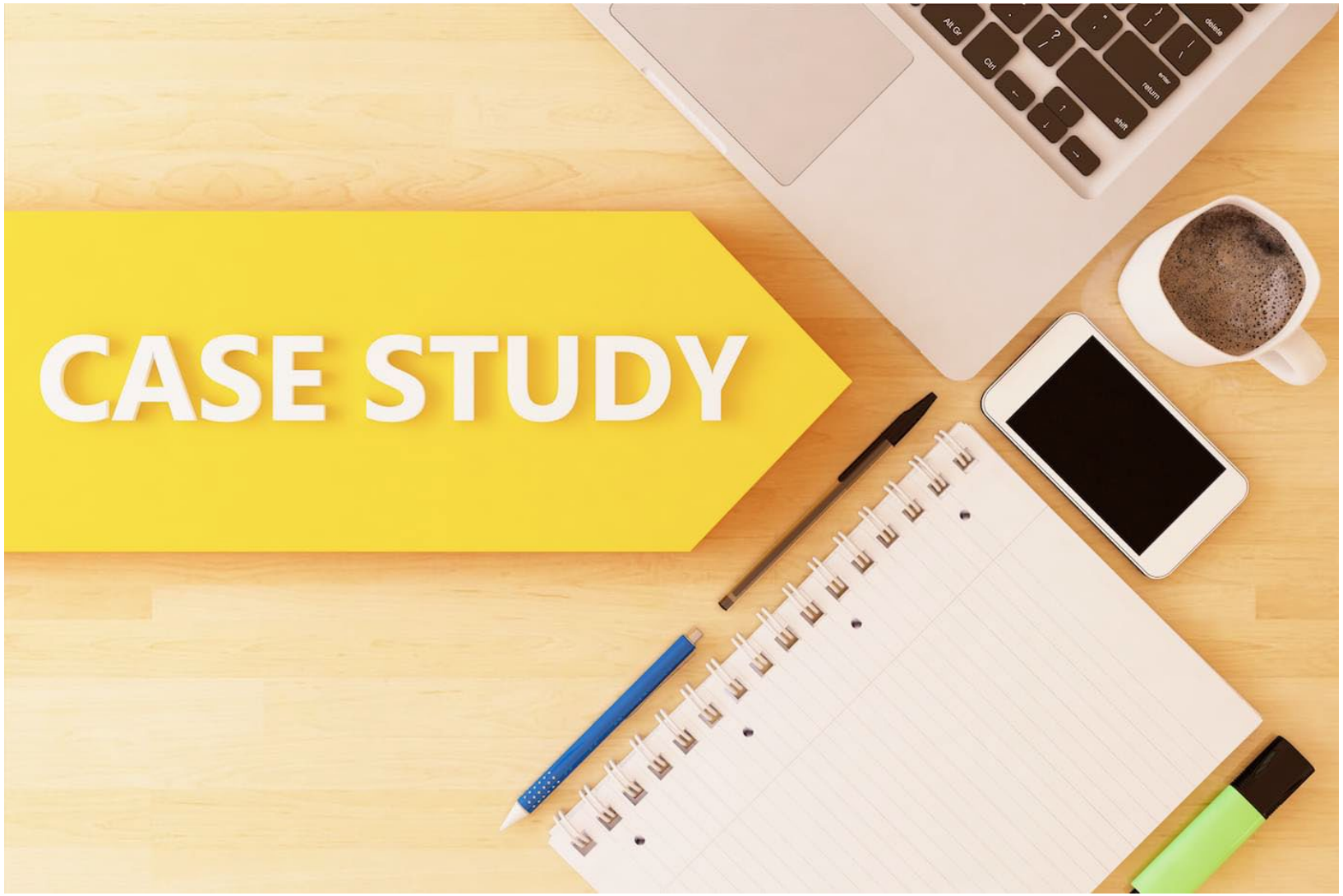
BENEFITS OF FEL PROCESS

- FEL helps identify the best investment opportunities and eliminates those that are not viable before detailed engineering money is spent

- FEL results in projects that are more competitive
  - Lowers total installed costs (TIC)
  - Reduces time from project conception to completion
  - Improves predictability of project cash flow
  - Optimizes project schedule
  - Returns on investment are boosted by about 20 percent versus average performers

- FEL helps to ensure a project meets operating, safety, environmental, and maintenance objectives

CASE STUDIES



Case Study 1

BFW Pump Project

Project Scope:

- Add redundant boiler feed water pumps
- Identical pumps to existing units
- Modify piping & valves; tie into new pumps

Lessons Learned:

• Project approval cost projection	=	$3.1M
• FEL cost projection	=	$6.7M
• Project approval pump pricing	=	$400K each
• FEL pump pricing	=	$800K each
• Project approval schedule	=	34-36 weeks
• FEL project schedule	=	56-58 weeks

Case Study 2

Compressed Air Dryer Project

Project Scope:

- Replace existing compressed air system dryers
- Use desiccant dryer in lieu of refrigerant style
- Modify piping & valves, as necessary
- Foundations

Lessons Learned:

• Project approval design assumption	=	Cut roof / lower into place
• FEL design	=	Cut roof / rigging plan
• Project approval pricing for roof	=	$100K
• FEL pricing	=	$500K
• Project approval schedule	=	16 weeks
• FEL project schedule	=	28 weeks

Case Study 3

Station Air Compressors Project

Project Scope:

- Replace existing station air compressors
- Replace existing filters and air dryers
- Modify piping & valves; tie into new pumps

Lessons Learned:

• Project approval cost projection	=	$1.8M
• FEL cost projection	=	$3.5M
• Project approval design approach	=	“Easy” access under the road
• FEL design approach	=	Difficult access under the road
• Project approval schedule	=	42 weeks
• FEL project schedule	=	52 weeks

Case Study 4

Emergency Notification Project

Project Scope:

- Noise study
- Updated fire alarm system
- Plant wide emergency notification system
- Upgraded annunciation speakers
- Fleetwide upgrade

Lessons Learned:

• Project approval cost projection	=	$3.2M
• FEL cost projection	=	$4.8M
• Project approval unit pricing	=	$400K each
• FEL unit pricing	=	$800K each
• Project approval schedule	=	18 weeks
• FEL project schedule	=	18 weeks

LESSONS LEARNED

- Be careful of the assumption “it’s identical to XYZ”
- Confirm equipment lead times early (and often)
- Get engineering involved as early as possible
- Evaluate constructability early in the design/conceptual phase
- Rely on your estimating team for current equipment & material pricing

SUMMARY

The benefits of using an FEL (stage gate) approach include:

- Improved project cost forecasting/predictability
- Reduced overall project cost
- Improved project schedules
- Enhanced risk management (lower project risk)
- Better scope definition
- Better decision making
- Stakeholder alignment

SUMMARY

"In essence, implementing FEL is a strategic investment that helps ensure successful capital projects through detailed planning, thorough analysis, effective risk management, and stakeholder alignment from the start."

- Google Gemini

"In short, FEL transforms a vague idea into a well-defined, executable plan. It's the difference between winging it and winning it."

- Microsoft Copilot

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ANY QUESTIONS?

Please stop by and visit us at Booth 4