



Next Rung Technology

Engineering Sustainable Solutions that Scale!

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MISSION



We envision a world where engineers play a key role in creating a healthy and sustainable planet.

*Our mission is to solve complex environmental challenges by providing **hands-on engineering support & analysis** to companies scaling **sustainable technology solutions**.*



Capital Discipline for Scaleup & FOAK Success



AGENDA



1

Intro and Background

2

The Bakers Dozen Dataset

- About our Data
- Impact of best practices for pilot / FOAK

3

Form Follows Function

- Show Horse vs. Work Horse
- Case study: A Tale of 4 Horses

4

Capital Discipline – Understanding Cost

- By Technology Stage
- By Project Area
- By Capital Intensity / Project Complexity

5

Capital Discipline – Understanding Schedule

- Top 10%, 50% & 90%
- Make vs. Buy Options

6

The Way We Think About Things Questions & Discussion – Let's Collaborate!

A stylized graphic of a ladder on the left side of the image. It consists of two parallel diagonal lines in a dark teal color, with five horizontal rungs in a slightly lighter teal color. The ladder is positioned on the left side of the frame, extending from the bottom to the top.

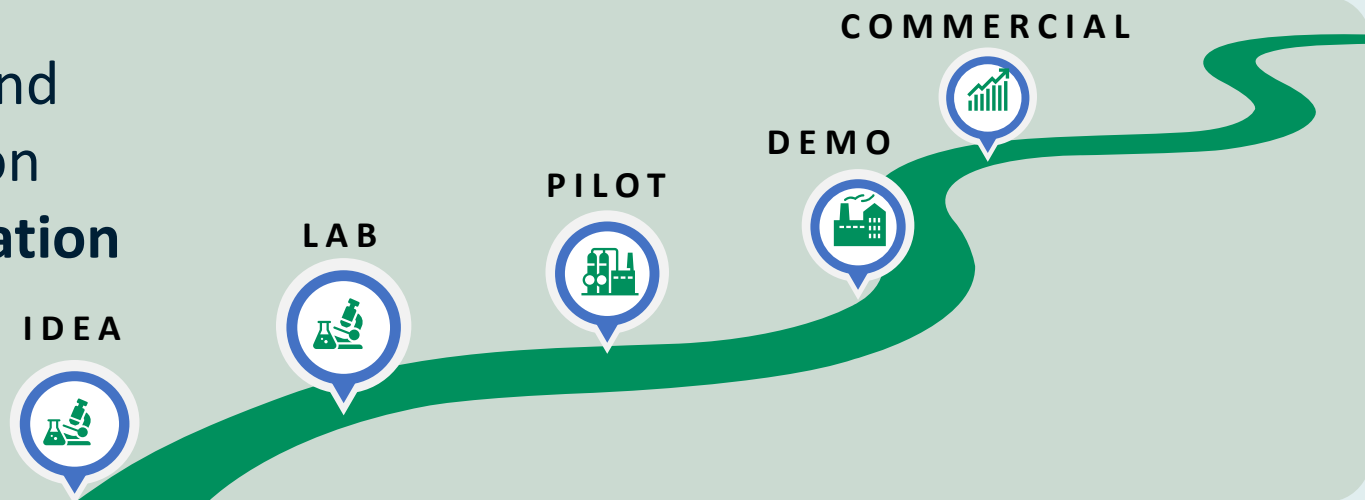
INTRODUCTIONS



OVERVIEW



Next Rung is an engineering and consulting company focused on the **scaling and commercialization of sustainable process technologies.**



Since 2017 we have helped over **150** customers scale their emerging technologies.



Member of **Greentown Labs, The Engine, mHUB**
Active participant in **national** and **international** innovation ecosystem.



DELIVERING SUSTAINABLE TECHNOLOGIES

Next Rung Technology provides engineering, execution, operations & consulting services to organizations developing and delivering sustainable technologies.



MARKETS INCLUDE:



Next Generation
and Sustainable
Materials



Low Carbon
Technologies
(Capture, Sequestration,
Removal, Utilization)



Industrial Bio-
technology



Next Generation
Foods and
Animal Protein
Alternatives



Renewable Fuels
& Chemicals



Water &
Wastewater
Technologies



... and more!

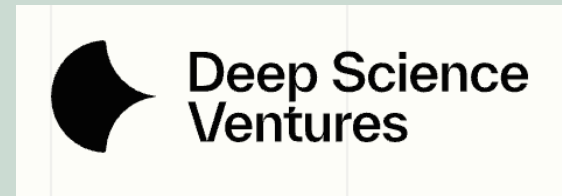
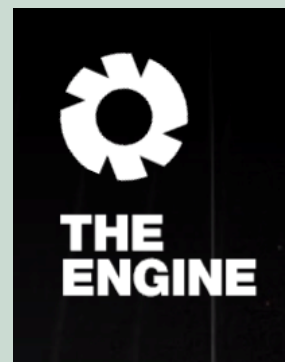
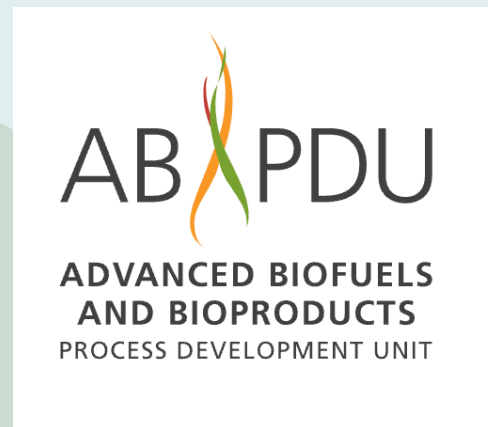


EMBEDDED IN INNOVATION ECOSYSTEM



Newlab

SPRIN-D





SCALING HEALTHY & BAKERS DOZEN

Thinking About A National Strategy

Once the Science is Solved, It Takes a Different Set of Skills and Support to Scale
As Well As Individual Scale Up Strategies

Thinking About Early Stage Technologies

Helping Emerging Technologies Navigate Pitfalls



2024



2025

THE BAKERS DOZEN BEST PRACTICES

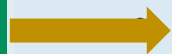
1. Scoping & Launching

- The End in Mind →
- Building & Using Your Roadmap
- Who Are Your Customers & What is the Real Product? (The Cupcake Factory)

2. Design & Development

- Understanding Your Readiness
- Day 1 and Year 2 Design
- Conceptual Design – Don't Get that Site Quite Yet! (The Pain of the Wrong Site)

3. Execution & Delivery



Form Matches Function

- The Big Six: Scope, Schedule, Budget, Risk Resources & Quality
- Always Keeping the Owner's Optionality

4. Ideas for the Industry

- Facility Co-Development & Sharing
- Execution When A Major Area Isn't Quite Ready
- Who Survives for the Long Game

THE BAKERS DOZEN DATA

WHAT DATA?



Our data comes from >12 pilot plant projects or first of a kind scale-up (FOAK) projects in the cultivated meat, food, and general industry



For these projects Next Rung played a role from conceptual engineering, through engineering design, technology scaleup, and project delivery.



We use data sets like these to turn anecdotal and general good guidance into datasets with frequency of occurrence, severity etc

THE BAKERS DOZEN DATA

Product	Pilot	FOAK	COMMERCIAL
Fats and Oils	X		
Mycelium	X	X	
Cotton	X		
Yeast	X		
Silk	X	X	
Chemicals		X	
Minerals	X		
Cell Ag	X		
Recycled Textiles	X	X	
Alt Proteins	X		
Materials	X		
Biosurfactants	X		
Alt Proteins			X
Biome Drug		X	





IMPACTS OF BEST PRACTICES

Assessing Outcomes

Positive

- Completed within 15% budget
- Completed within 15% schedule
- Plant functions as desired
- Completed as ORIGINALLY planned
- Rescoped and completed
- Company KEPT business line

Neutral

- Not yet launched
- Not completed

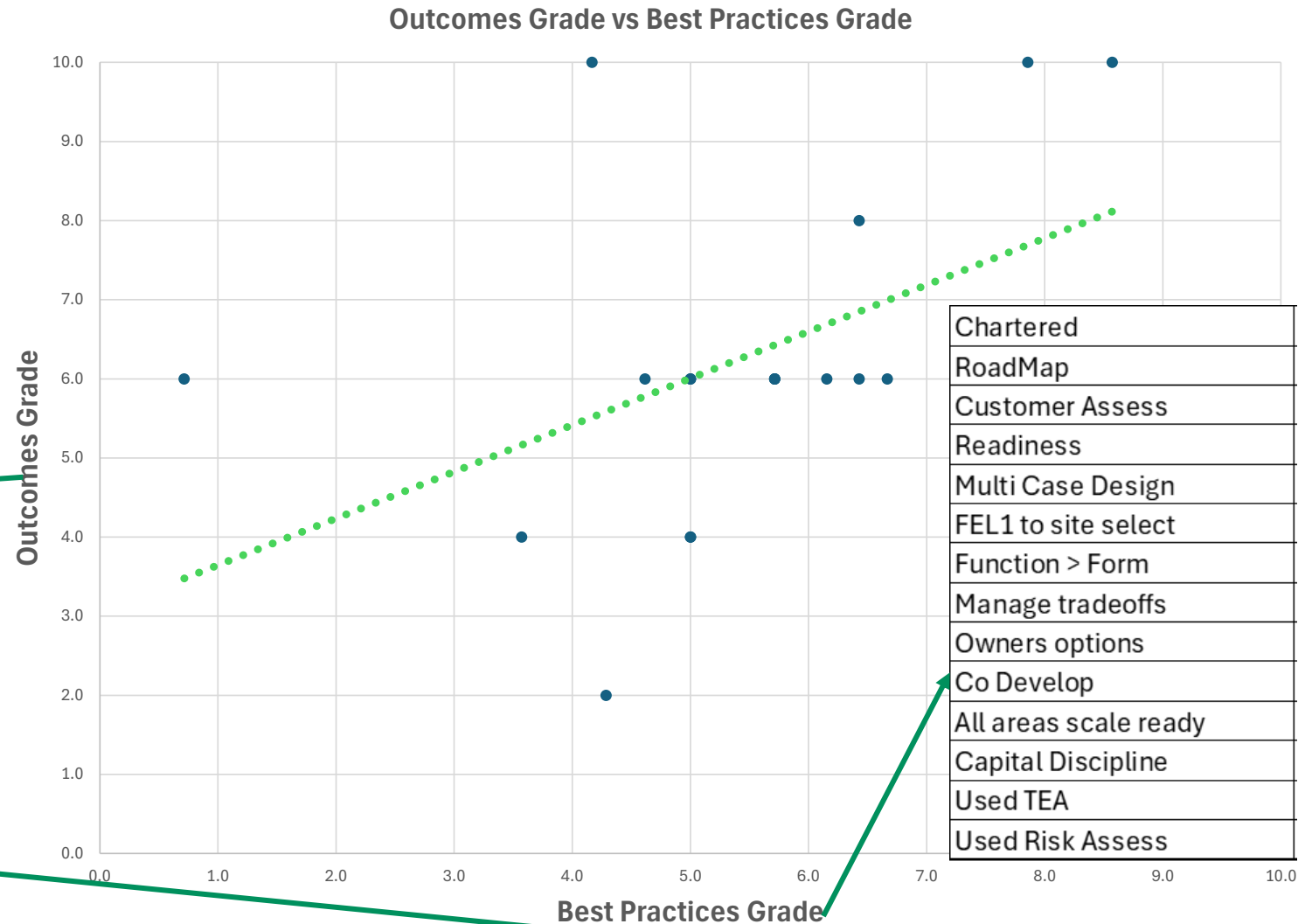
Negative

- Business line cancelled
- Company no longer in business

Assessing Best Practices

1. Identify whether each best practice was used (1-12)

1. → Normalized to a scale of 1 to 10





FORM MATCHES FUNCTION

Is your project a show horse or a work horse?



?

What is the class of
your facility?

Match size to scaleup
and production needs





FORM MATCHES FUNCTION

Is your project a show horse or a work horse?



DON'T MAKE THINGS BIGGER THAN THEY NEED TO BE ...
TO PROVE WHAT YOU NEED TO PROVE (ARRA PROJECT)

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FORM MATCHES FUNCTION

A TALE OF 4 HORSES

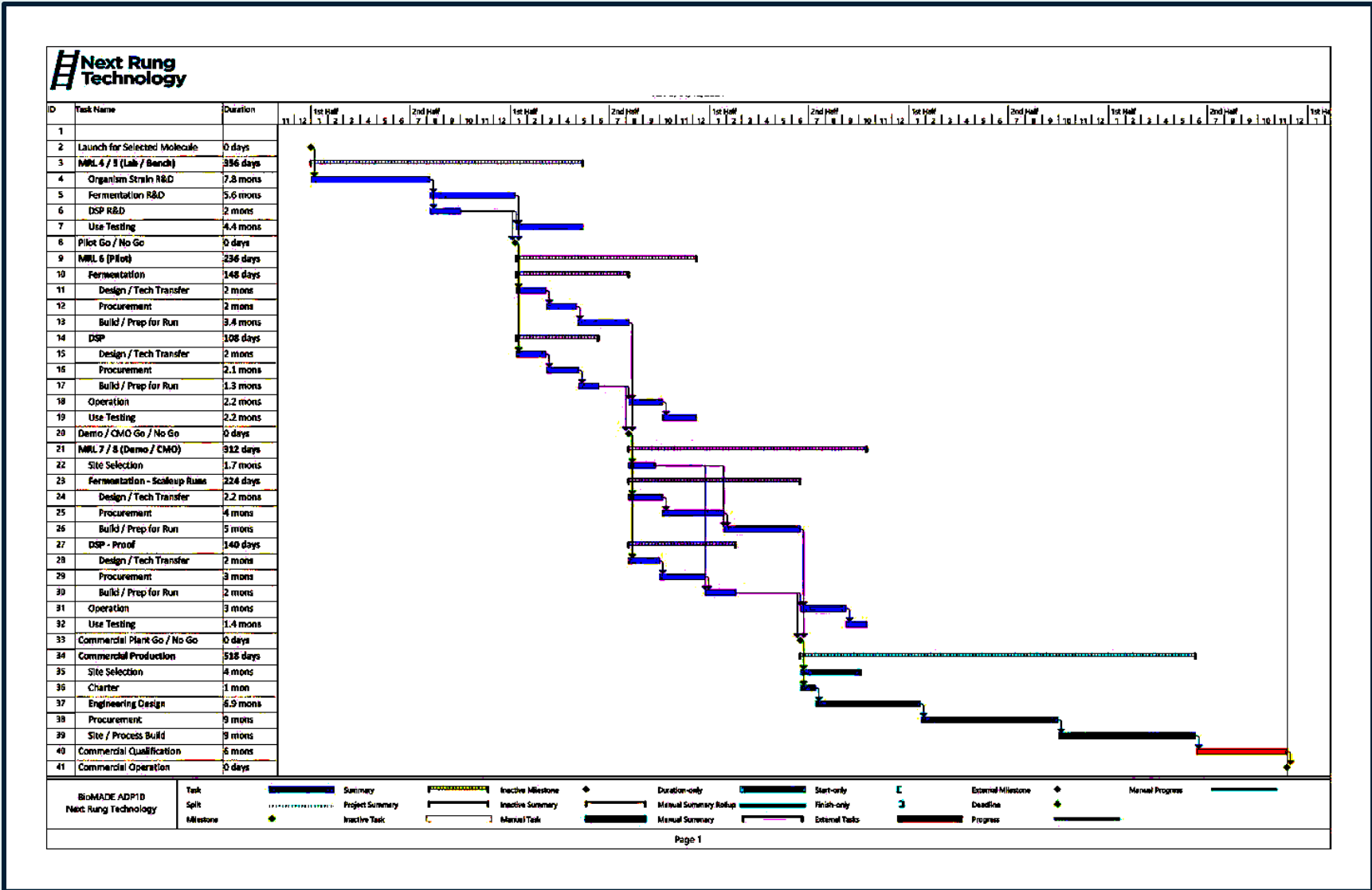
	Showhorse	Workhorse	Race Horse	Pulled Up Lane Down the Stretch
	Next Generation Fats & Oils	BioMass Fermentation	Textile Recycling	Next Generation Proteins
SIZING	For customer visits and samples, not a strong technical basis	For production	For what was needed to prove their tech	World's largest
RISK MGMT	Cut back scope for \$\$, to fit space	Internal team had excellent production experience	Internal team scrappy, listened to guidance	Capital cost warning signs were ignored
SITE SELECTION	High-profile	Existing shell in relevant region	Scrappy warehouse	Former pharma facility

OVERALL GRADE	C	A-/B+	A-/B+	C-
SYNOPSIS	For show, not for go	Well done	Proved what they need to prove	Built to impress not to inform Overseas skid delivery thwarted changes



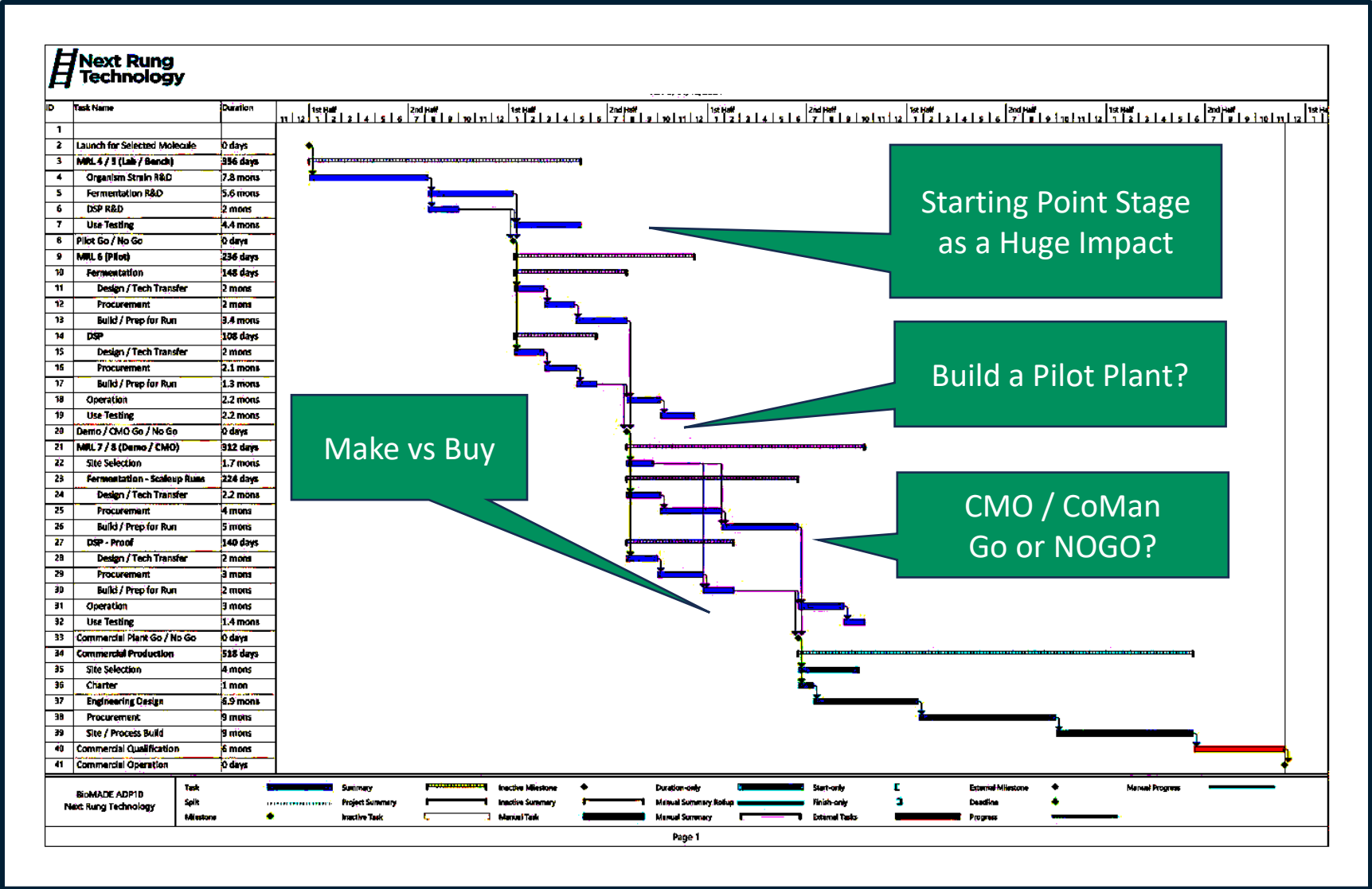
How Does This Play Out Over a Program

A National Initiative





UNDERSTANDING COST – THE STEPS OF SCALING

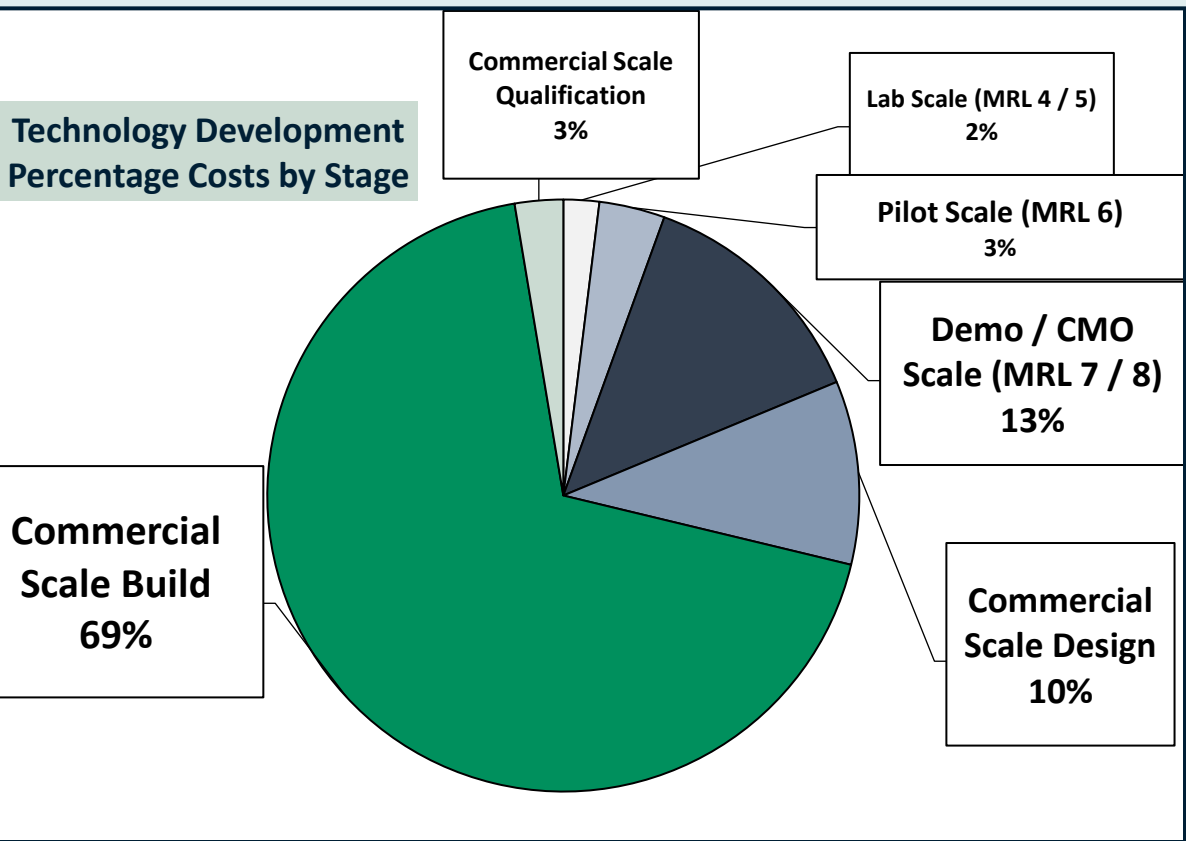




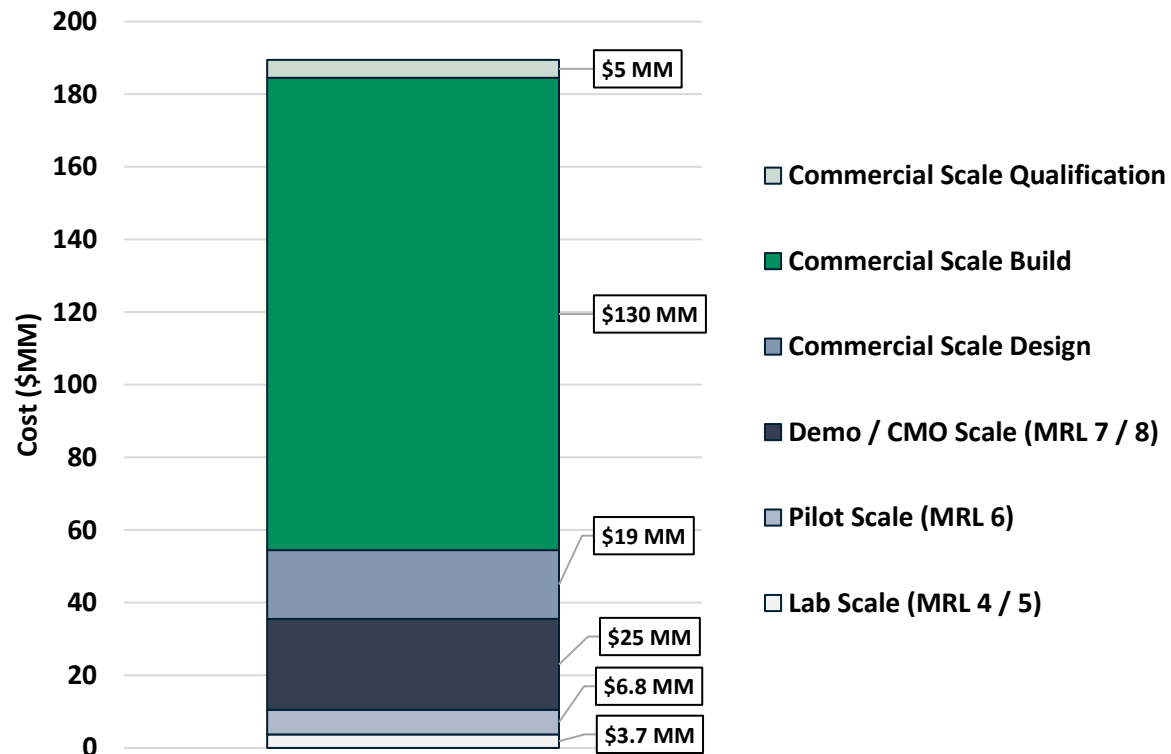
UNDERSTANDING COST

BY TRL

Technology Development Percentage Costs by Stage



Technology Development Cumulative Costs by Stage



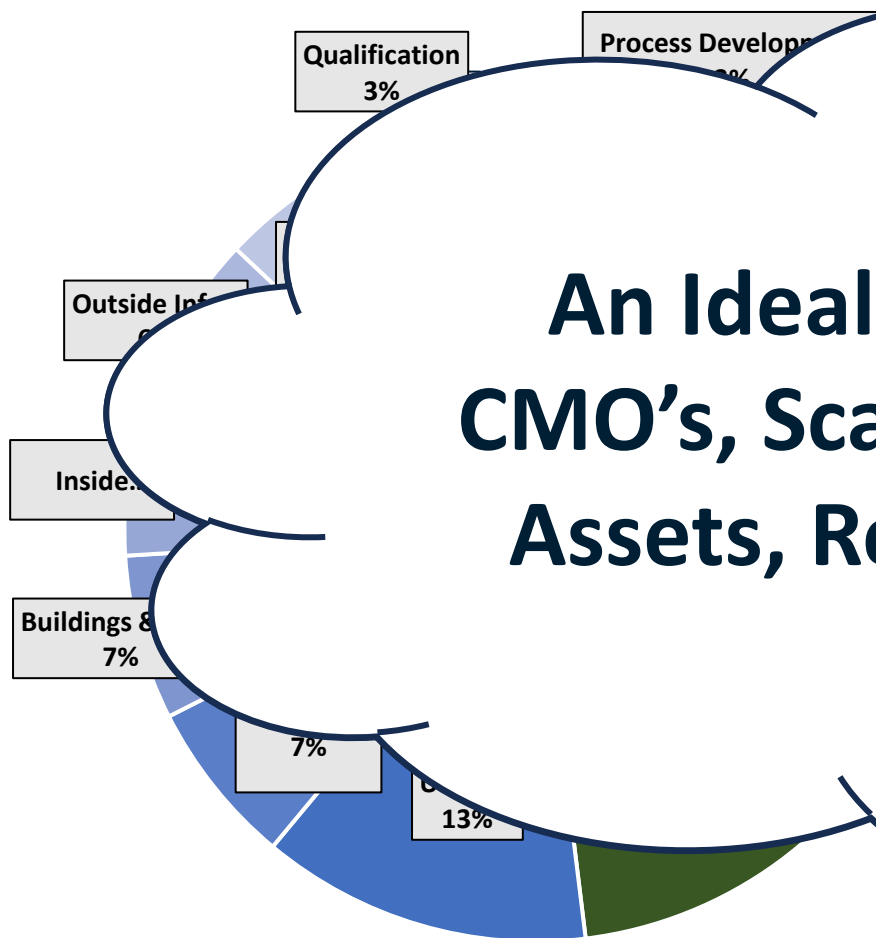
Data represents technical elements of scaling *only* (not regulatory, consumer etc)



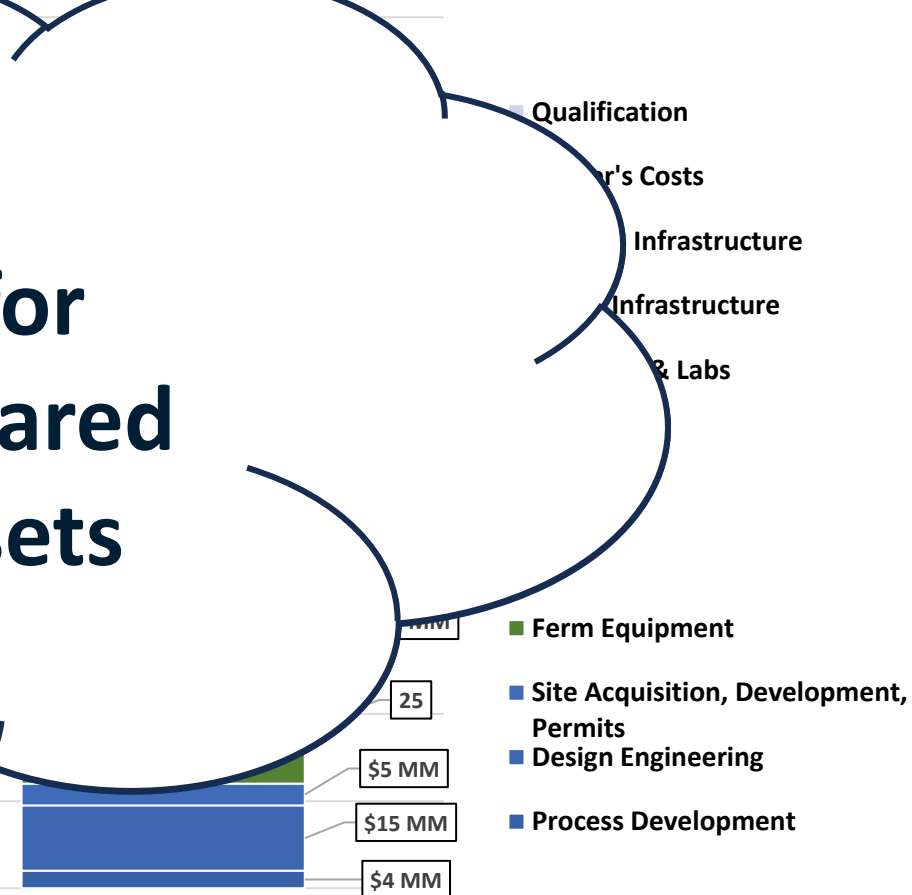
UNDERSTANDING COST

BY PROJECT AREA

Commercial Project Percentage Costs by Stage



Commercial Project Cumulative Costs by Stage



**An Ideal Opportunity for
CMO's, Scaleup Hubs, Shared
Assets, Repurposed Assets**



UNDERSTANDING COST

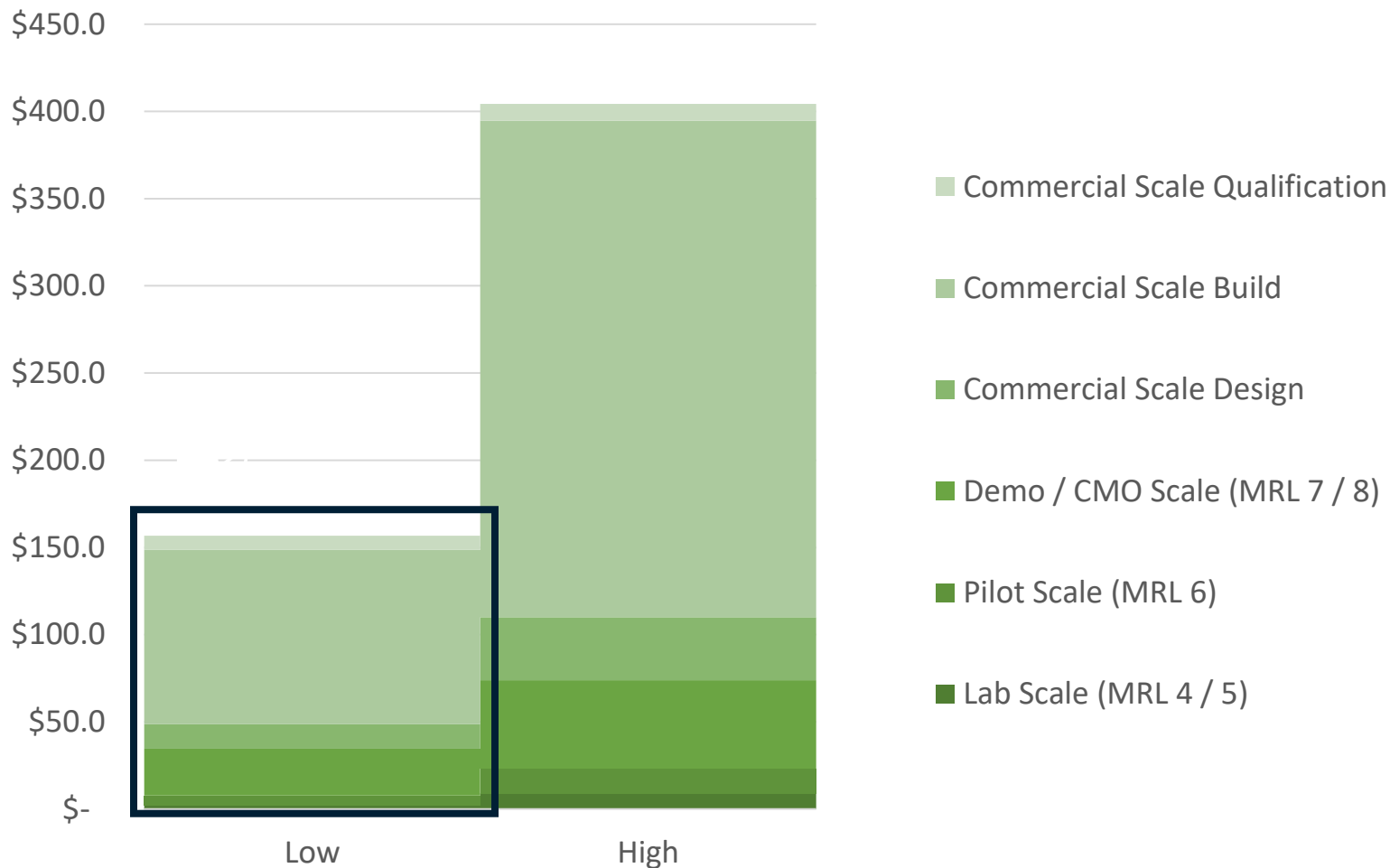
BY CAPITAL INTENSITY



Low Capital Cost

Lab Pilot scale are relatively similar in cost in each case.

It's not until you get to demonstration and commercial scale that the cost starts to move differently, depending whether you have a low or high cost capital projects, depending on the complexity of process.





UNDERSTANDING COST

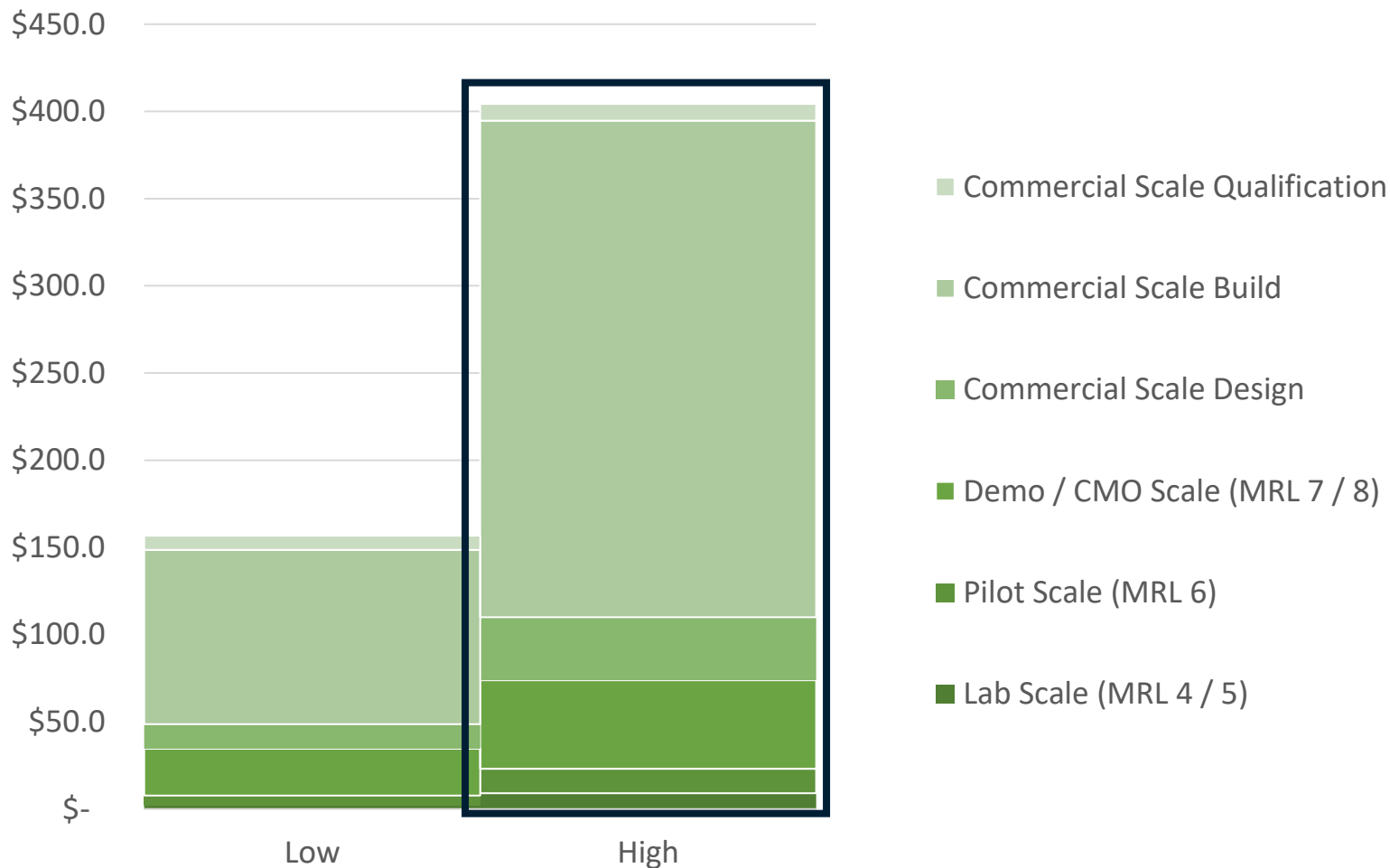
BY CAPITAL INTENSITY



High Capital Cost

Lab Pilot scale are relatively similar in cost in each case.

It's not until you get to demonstration and commercial scale that the cost starts to move differently, depending whether you have a low or high cost capital projects, depending on the complexity of process.





UNDERSTANDING SCHEDULE

TOP 10%

Total duration to next stage (months)





UNDERSTANDING SCHEDULE

TOP 50%

Total duration to next stage (months)



* Data represents technical elements of scaling only (not regulatory, consumer etc)





UNDERSTANDING SCHEDULE

TOP 90%

Total duration to next stage (months)

Lab Scale (MRL 4/5)

Organism Strain R&D
Fermentation R&D
DSP R&D
Use Testing

90

| 5 years

| 10 years

| 15 years

| 20 years

| 25 years

Pilot Scale (MRL 6)

Fermentation Design
Tech Transfer
Fermentation Procurement
Fermentation Build
DSP Design
DSP Procurement
DSP Build
Operations
Use Testing

56

Demo / CMO Scale (MRL 7/8)

Site Selection
Fermentation Design
Tech Transfer
Fermentation Procurement
Fermentation Build
DSP Design
DSP Procurement
DSP Build
Operations
Use Testing

How Might
Technologies
Such as AI
Change This?

80

Commercial Scale Design

Site Selection
Charter
Engineering Design
Procurement

40

Commercial Scale Build

Site / Process Build

29

Commercial Scale Qualification

Qualify

30

In large part these
are variations of
Make vs Buy
Decisions



Data represents technical elements of scaling
only (not regulatory, consumer etc)

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How Does This Play Out Over a Program, A National Initiative

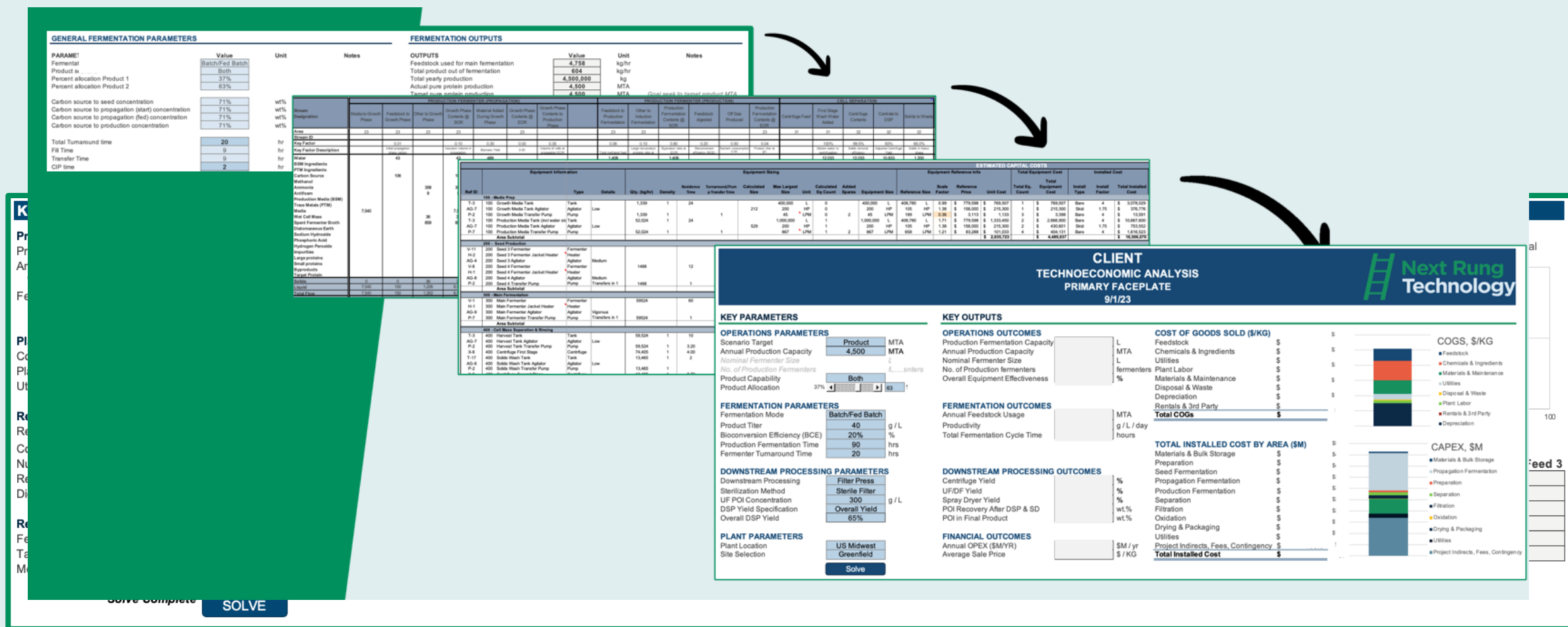
Learning From Previous Programs

- There is a (Capital and Technical) Valley of Death
 - But Also Markets & Product Acceptance
 - Ability to Execute Major Issue With Technology Companies
 - Funding Mismatches
 - Feedstock Development and Certainty
-
- Ideas Developed Include
 - Staged Investments Strategically Selected to Avoid the Solyndra Experience
 - Dual Use Products and Technologies
 - Catalyzing Partnerships
 - Shared Infrastructure / Brownfields Reuse
 - Platform Scaleup Facilities With Regional Focus
(Feedstocks, Products, Existing Manufacturing Assets)
 - Combining Technologies, Feedstock & BioMass Handling, Biology, Chemistry



Ways We Think About Things

Developing Technical Tools That are Organizational Tools ... Visuals





Ways We Think About Things



**Next Rung
Technology**

SITE MATCHING TOOL

SITE & TECHNOLOGY REQUIREMENTS, EVALUATION & ASSESSMENT MODEL

PRIMARY FACEPLATE Issue 0

SITE & TECHNOLOGY DEFINITION

User input area to define production goals and site.

Technology Selection	Plasticizer	MRL	4
Target Production Capacity	1,000	MTA	
Fermentation Capacity	1,012	m3	
Technology Selection	Aldehyde	MRL	9
Target Production Capacity	10	MTA	
Fermentation Capacity	16	m3	
Technology Selection	Plasticizer	MRL	4
Target Production Capacity	500	MTA	
Fermentation Capacity	506	m3	

Evaluated Site Selection	Biopolymer
Site Fermentation Capacity	1,599 m3
Site Location	Lake Providence, LA

FEASIBILITY ASSESSMENT

Feasibility of a project is determined by equipment match and MRL level.

Site & Technology Match Type	DSP or Ferm
Infrastructure & Utility Requirement Met	92%
Fermentation Requirement Met	77%
DSP Requirement Met	45%

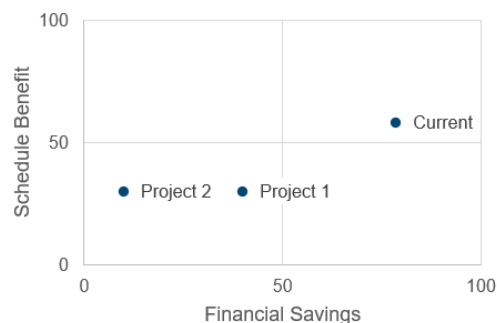
INFRASTRUCTURE MATCH	MRL LEVEL		
	4 / 5	6 / 7	8 / 9
	Greenfield Only	LO	MED
	Infrastructure & Utilities	LO	MED-HI
	DSP or Fermentation	MED	HI
DSP & Fermentation	MED-HI	HI	HI

SITE OPTION EVALUATION SUMMARY

Evaluation based on projected financial savings and schedule benefit.

Project Scoring	Current	Project 1	Project 2
Financial Savings Rating	79	45	10
Schedule Benefit Rating	58	55	30

Financial Savings Vs. Schedule Benefit



FACILITY REQUIREMENT VS. SITE OPTION EVALUATION

Average equipment and infrastructure capacity matches based on existing systems.

EQUIPMENT REQUIREMENTS	Average Capacity Match	Equipment Systems Matched
00 Storage & Prep	48%	3 / 3
10 Feedstock Conversion	N/A	0 / 0
20 Media Prep	21%	1 / 2
30 Seed Fermentation	55%	1 / 1
40 Core Fermentation	100%	1 / 1
50 Cell Disruption & Separation	100%	1 / 2
60 Purification	N/A	0 / 2
70 Product Processing	11%	1 / 1
80 Utilities	100%	1 / 1
90 Waste Collection and Treatment	N/A	0 / 0

INFRASTRUCTURE REQUIREMENTS	Capacity Match	Capacity Needed for Product	Capacity Available at Site
Plant Water (LPD)	90%	200,000	2,500,000
Wastewater Flow (LPD)	90%	200,000	2,500,000
Power (MW)	90%	0	4
Natural Gas (SCFH)	90%	4,690	70,380
Land (acre)	90%	1	9
Truck Traffic (trucks per day)		0	100



AREAS WE ARE EXPLORING / AREAS OF ACTIVITY

Areas of Activity We Are Exploring

- Successes in operations, the supply chain
- Successes in delivery (SAF, DVC, etc) / are skid / mobile approaches

- Next Generation Technologies (AI)
- Next Generation Circulative Technologies



2024



2025



WHAT WE TALKED ABOUT TODAY



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Questions / Discussion / Collaborate?



COMMERCIALIZATION TOOLKIT



Strategic Planning

- Roadmapping
- US Market Approach
- Organizational & Operational Leadership
- Risk Management



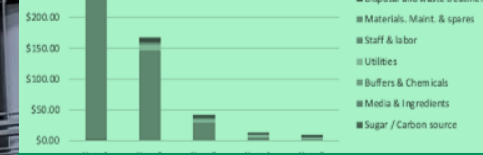
Tech Development

- Process Design
- Scale Up
- R&D Tech Support
- 3rd party site selection (CMO)



Project Development

- FEL 0/1/2/3
- Design Packages
- Value Engineering
- Grant Application Support



Consulting & Modeling

- Techno-Economic Analyses & Modeling
- Site selection analysis
- Capital Cost Estimations
- Pro Forma's

Project Execution

- Owners PM
- Owners Engineer
- Procurement
- Skid Development
- Long-lead procurement
- A&E Outreach / Eng Co



QUESTIONS / DISCUSSION?
CONTRIBUTE TO THE DATASET / COLLABORATE?



Our vision is a **healthy and sustainable** planet, created by talented engineers and entrepreneurs.



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