Integrated Biorefinery for the Direct Production of Synthetic Fuel from Waste Carbonaceous Feedstocks

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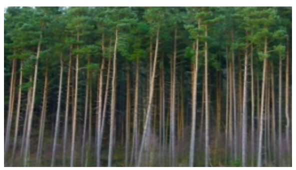
General Overview
Project Description and Objectives


Biomass Residues


Biomass Crops


CO_2 Emissions


Natural Gas


Flared NG

Stage 1
Syngas Production

Thermochemical Conversion

Stage 3
Catalytic Conversion

Direct "Drop-In Fuel Production (new PRF technology)

Wax Production (old technology - Sasol, Shell, etc.)

Stage 4
Distribution of Synthetic Fuels

Premium, Synthetic Fuel

Refinery Processing
Hydro-Cracking
Isomerization

General Overview
Project Description and Objectives

REII Ecological, Economical and Efficient

REII Headquarters:	Sacramento, CA
Project Location:	Toledo, OH
Feedstock:	Wood (0.15”-2.00” chips) and Rice Hulls (whole)
Feedstock Input:	2.5 - 25 ton / day
Product Output:	56 gal/daft of transportation fuel

Rice Harvest Residues

Wood Residues

Thermochemical Conversion (TCC)
Pyrolysis & Steam Reforming

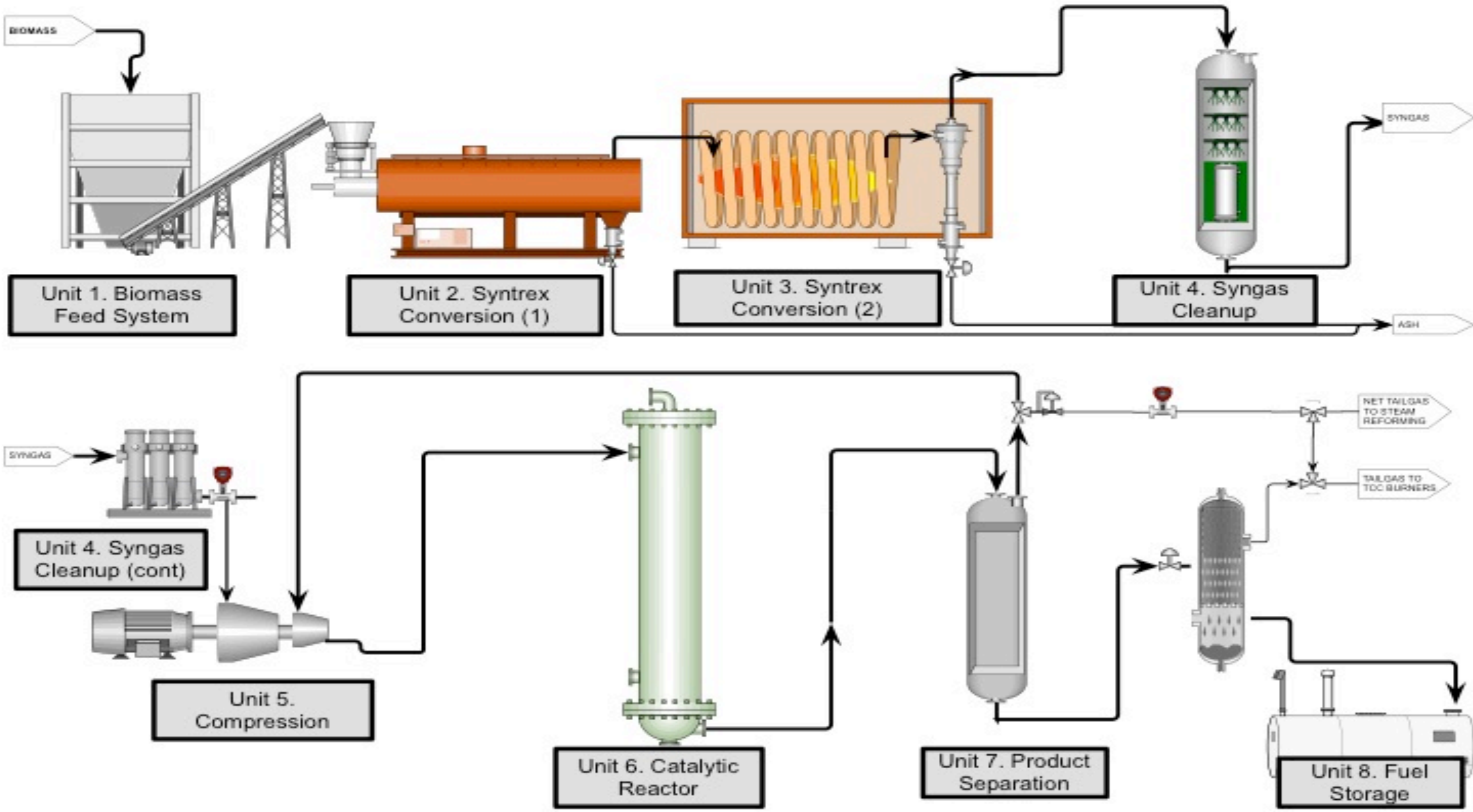
RED LION BIO-ENERGY

Syngas

Liquid Fuel Production (LFP)
Direct Fuel Production

PACIFIC RENEWABLE FUELS

Direct Production of "Drop-In" Synthetic Fuels from Carbonaceous Resources using Thermochemical Processes – Unit Processes



Project Description

25 tpd Integrated Biorefinery (IBR) Plant [Construction Completed (3/2012)]

Thermochemical Conversion (TCC) System
(Unit Processes #1-4A)

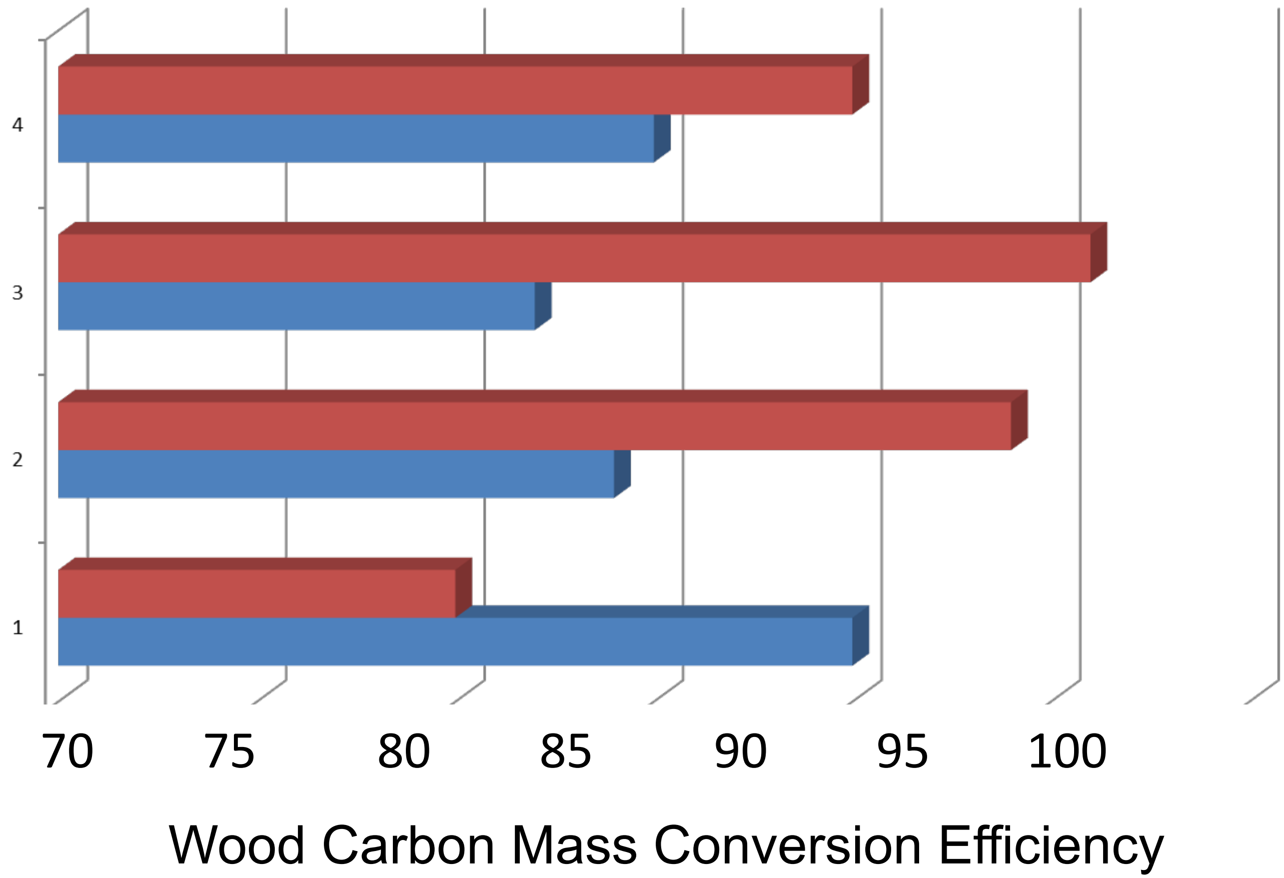
Liquid Fuel Production System
(Unit Processes #4b-#8)

Carbon Mass Conversion Efficiency (Wood)

REII Ecological, Economical and Efficient

Ash (Average % C Conversion = 85%)

Syngas (Average % C Conversion = 90%)



2- Technical Performance
Synthetic Diesel Fuel Tests on Heavy-Duty Diesel Engines

2 – Technical Performance
Results of Heavy Duty Diesel Engine Tests

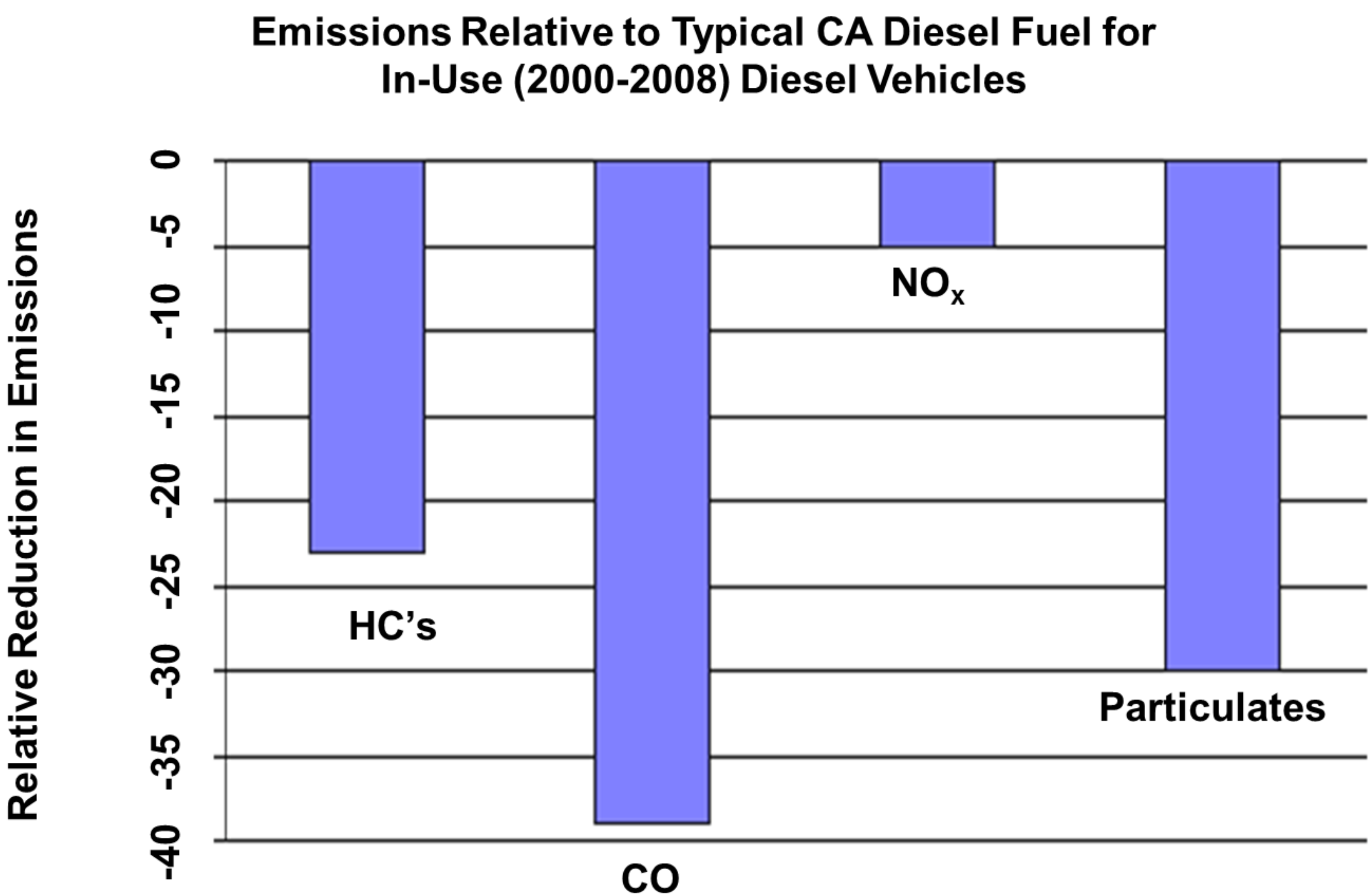
The % Difference in Emissions between the 20% Synthetic Diesel Fuel Blend and Certification Diesel Fuel

% Difference (20% Blend vs. Certification Fuel)	Emission Species (grams/Kw-hr)						
	THC	CH_4	NM HC	NOx	CO	CO_2	PM
Engine Out Emissions	-10.0	-9.2	-10.0	No Diff.	-11.0	-0.8	-21.0
Tail-Pipe Emissions (after control)	Near zero	Near zero	Near zero	Below 0.20 EPA std.	-16.0	-0.8	Near zero

The Difference in Fuel Economy, Work and Power at 1,200-1,600 rpm for the 20% Synthetic Diesel Blend compared to the EPA/CARB Certification Fuel

BSFC Fuel Economy (miles/gallon)	Work Output (KW-hr)	Power Output (KW-hr)
+ 0.7	+ 0.3	- 0.6

2 – Technical Performance
Synthetic Diesel Fuel Tests on In-Use Diesel Vehicles



Technologies Successfully Validated & Additional RD&D Needed for Successful Deployment of Commercial Scale IBR Plants

IBR Plant - Unit Processes	FEL Level
Additional RD&D Needed for Successful Commercial Deployment	
UP #1 – Upgrade and validate the current ram charge feeder to insure robustness and reliable operation over the life of the IBR plant	**FEL-1**
UP #2 – Increase the capacity of the ash removal system to handle high ash content feedstocks	**FEL-1**
UP #3 – Design, build and validate a less costly and more energy efficient gases steam reforming system	**FEL-1**
UP #9 – Select and validate an efficient and inexpensive fuel distillation process	**FEL-1**
Technologies Successfully Validated and Ready for Commercial Deployment	
UP #4a – The IBR syngas purification system is directly applicable to the commercial scale plants	**FEL-2**
UP #4b-#8 – The liquid fuel production system is robust and immediately applicable for the commercial scale application	**FEL-3**
The IBR control systems and plant safety systems are directly applicable to the commercial scale plants	**FEL-3**

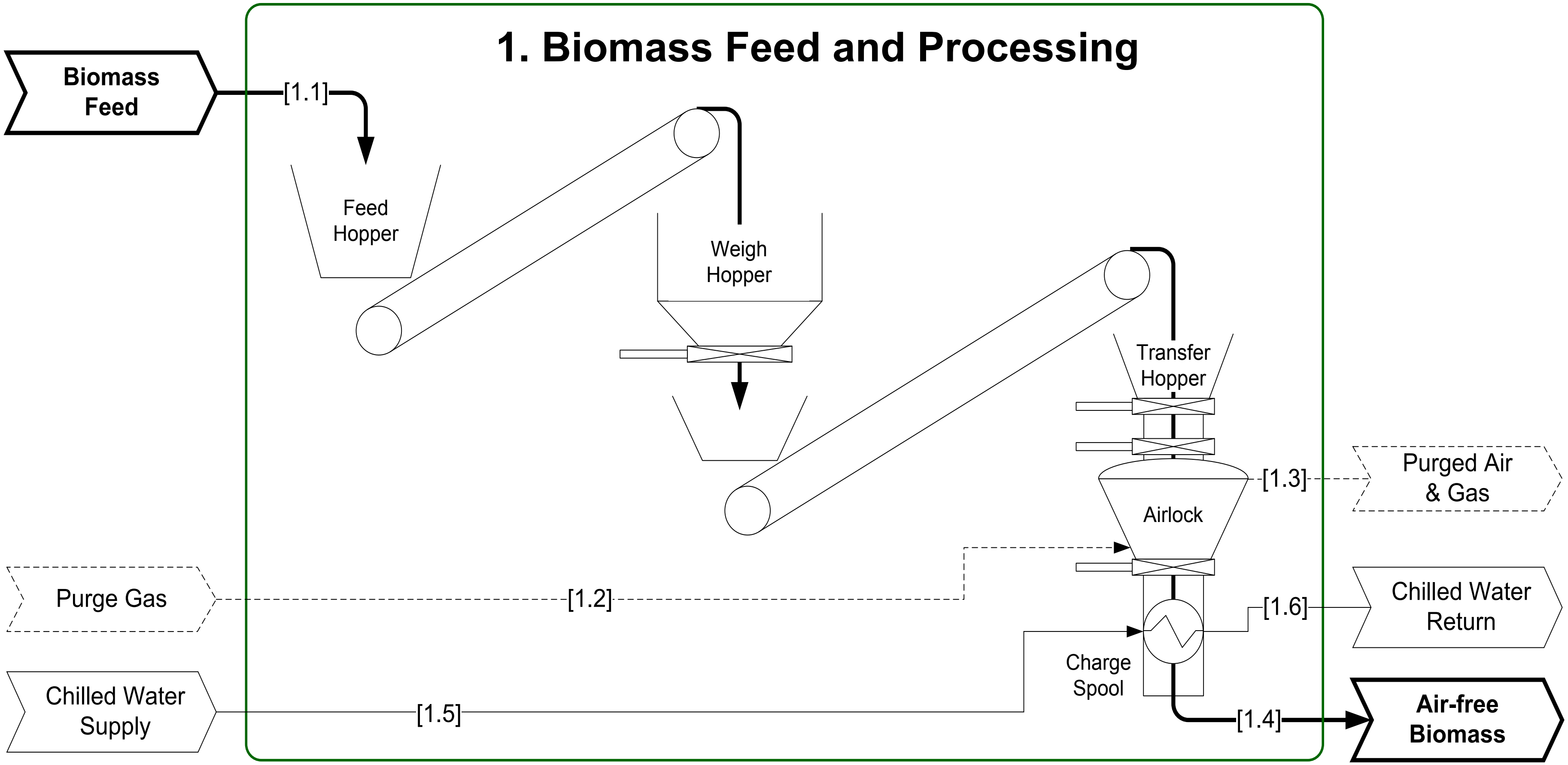
Technologies Successfully Validated & Additional RD&D Needed for Successful Deployment of Commercial Scale IBR Plants

IBR Plant - Unit Processes	FEL Level
Additional RD&D Needed for Successful Commercial Deployment	
Current syngas flow measurement systems are not reliable and more accurate and robust systems need to be developed and validated	**FEL-1**
Technologies Successfully Validated and Ready for Commercial Deployment	
Several, suitable U.S. equipment suppliers have been identified for the design and manufacture of the modular unit processes, instrumentation, control systems and components (e.g. valves)	**FEL-3**
A catalyst manufacturing capability has been validated for multi-ton quantity production of high quality catalysts	**FEL-3**

Technologies Successfully Validated & Additional RD&D Needed for Successful Deployment of Commercial Scale IBR Plants

IBR Plant - Environmental	FEL Level
Additional RD&D Needed for Successful Commercial Deployment	
Determine the potential of using the LFP water discharge for agriculture and other "gray water" uses	**FEL-1**
Technologies Successfully Validated and Ready for Commercial Deployment	
Incorporate low emission gas burners for heating unit processes #2 & #3	**FEL-3**

Upgrade and Validate the Biomass Feed Introduction System



Upgrade and Validate the Biomass Feed Introduction System

Upgrade and Validate the Biomass Feed Introduction System

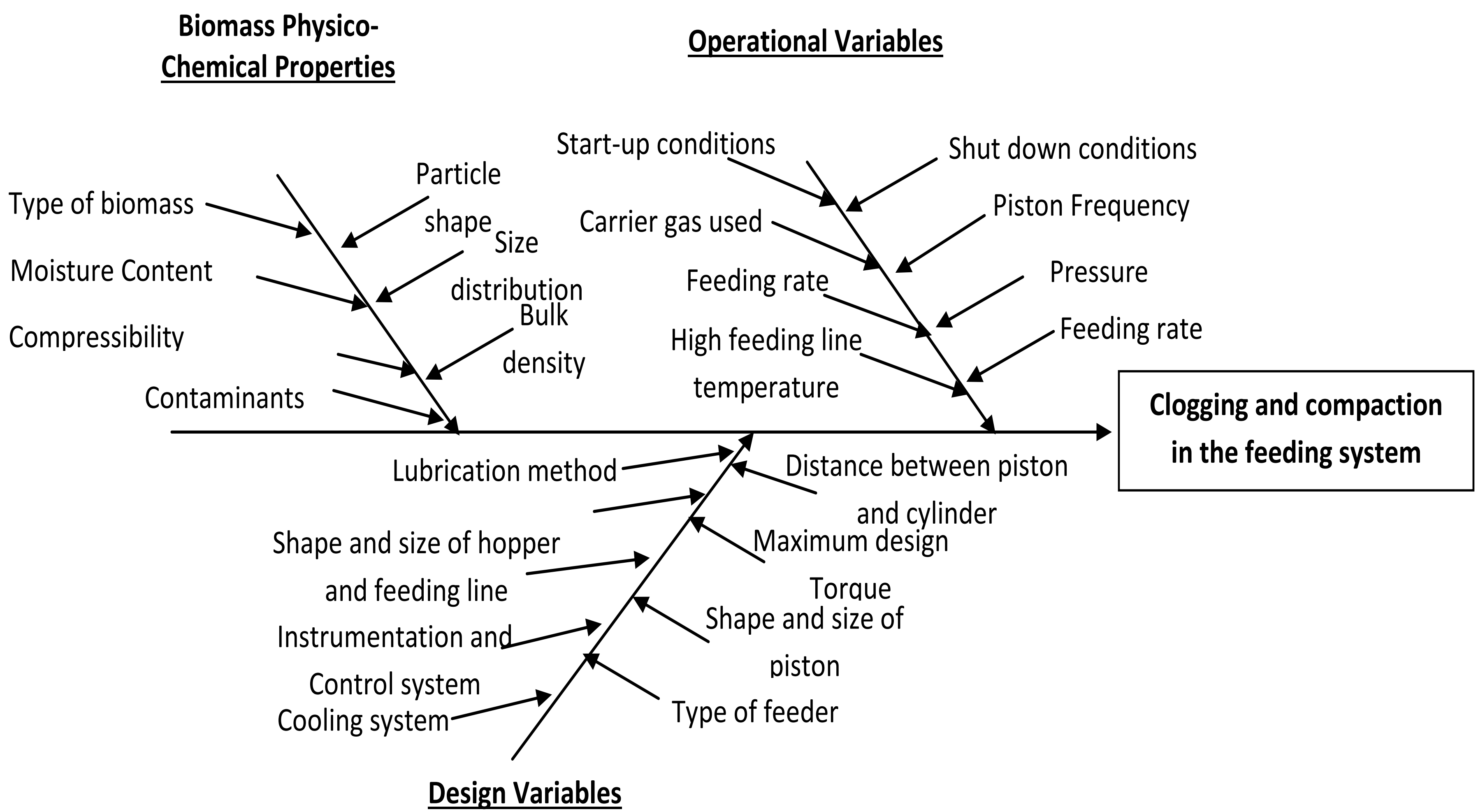
Upgrade and Validate the Biomass Feed Introduction System

Unit Process #1 **Biomass Feed & Processing**	**Technical Target**	**Results Achieved**
Biomass input rate	25 dtpd	24 dtpd
Remove air (O_2) with CO_2 purge	< 500 ppm O_2	< 500 ppm O_2
Biomass size input	1.25" Minus	0.15-2.50"

Findings:

- Very finely ground feedstock (<0.15") can collect on the ram charge feeder seals causing leaks and become entrained into the gas stream and into unit process #3 which can adversely impacts carbon conversion and syngas purification efficiency.
- Feedstock greater than 1" in diameter is more difficult to convert.
- The introduction chamber needs to be emptied between runs.
- For commercial scale plants, the valves need to be re-designed and thoroughly tested to insure robust operation.

Biomass Feed Introduction System
Cause-Effect Diagram used for System Upgrading



Recommended Upgraded Design for Biomass Feed Introduction System