Final Design Review and Project Proposal

Nestle Purina Team 2

Daniel Andenmatten, Brandon Hoffman, Nathan Kish, Chris Simpson, Pengfei Wu

NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences

Nestlé PURINA

Overview of Presentation

- **Needs Identification**
  1. **Problem Statement**
  2. **Criteria Tree**
  3. **Functional Diagram**

- **Concept Generation**
  1. **Concept Generation**
  2. **Concept Selection**

- **Engineering Analysis**
  1. **Natural Gas**
  2. **Steam/Air Analysis**

Problem Statement

- **Problem**
  - **Dryer 3 uses significantly more energy than the other four dryers to extract moisture from the product.**

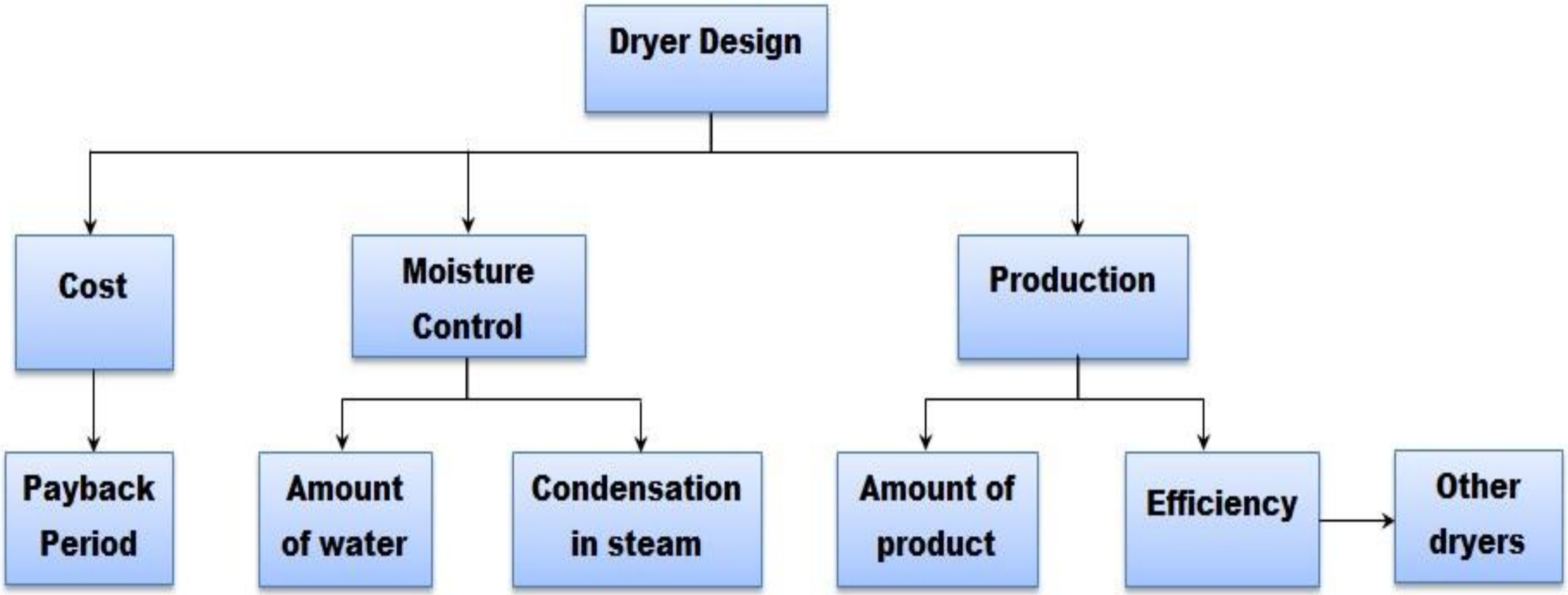
Problem Statement

- **Needs statement**
  - **Propose a solution to current throughput and energy efficiency issues.**
- **Goal**
  - **Increase η in dryer 3**
- **Constraints**
  1. **Moisture Content in the product < 11.5%**
  2. **Payback period for investment < 8 years**
  3. **There is no condensation in the steam coils**

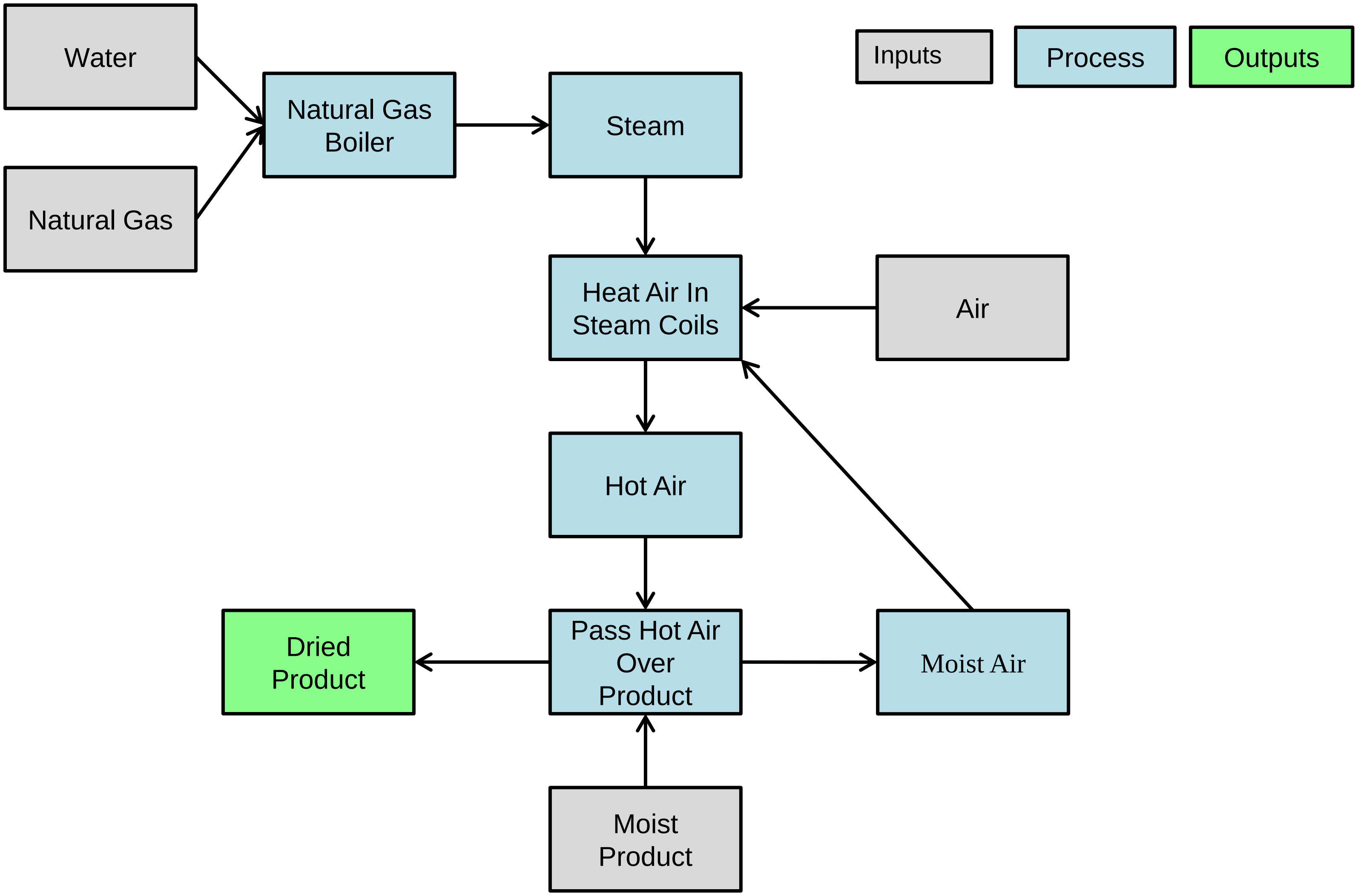
Objectives

Objectives	Basis for Measurement	Units
Inexpensive	Implementation costs	$
Production output	Weight of product	Tons
Moisture content	Amount of water	%
Efficiency	Energy used	BTU/ ton
Condensation	Weight of water in the steam	Kg water/ kg steam

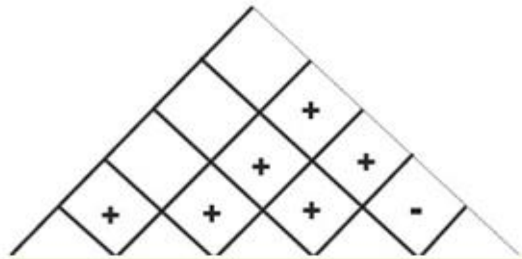
Criteria Tree



Functional Diagram



Quality Function Table

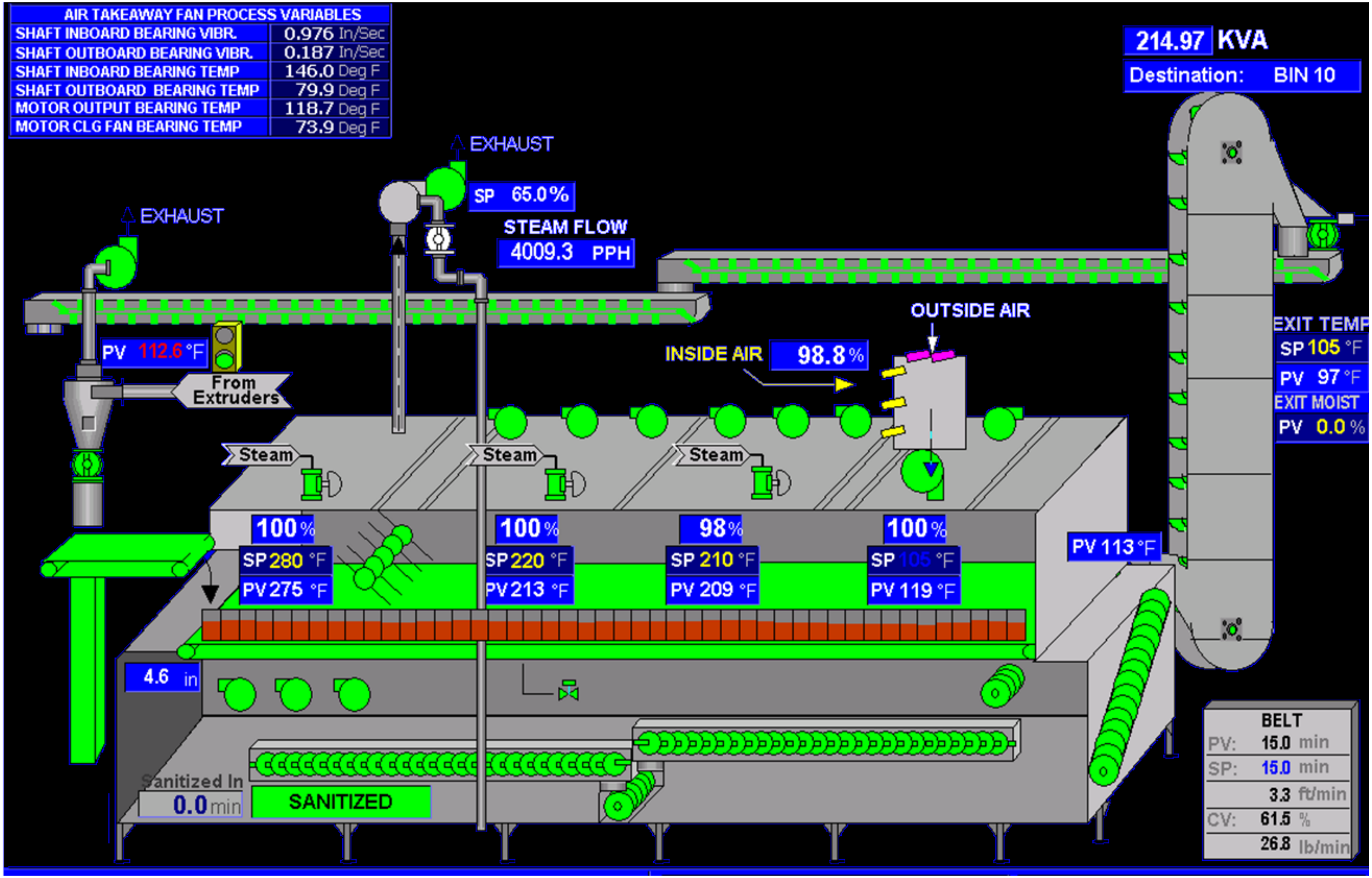


		Engineering Requirements				
		Weight	Cost	Payback Period	Energy reduction	Tonnage
Customer Requirements	Inexpensive	x	x	x	x	
	Allow for more product throughput		x	x	x	x
	Durable	x	x	x		
	Units	ton	$	yrs	%	ton
		100	250k	8	10	20/day
		Engineering Targets				

Concept Generation Overview

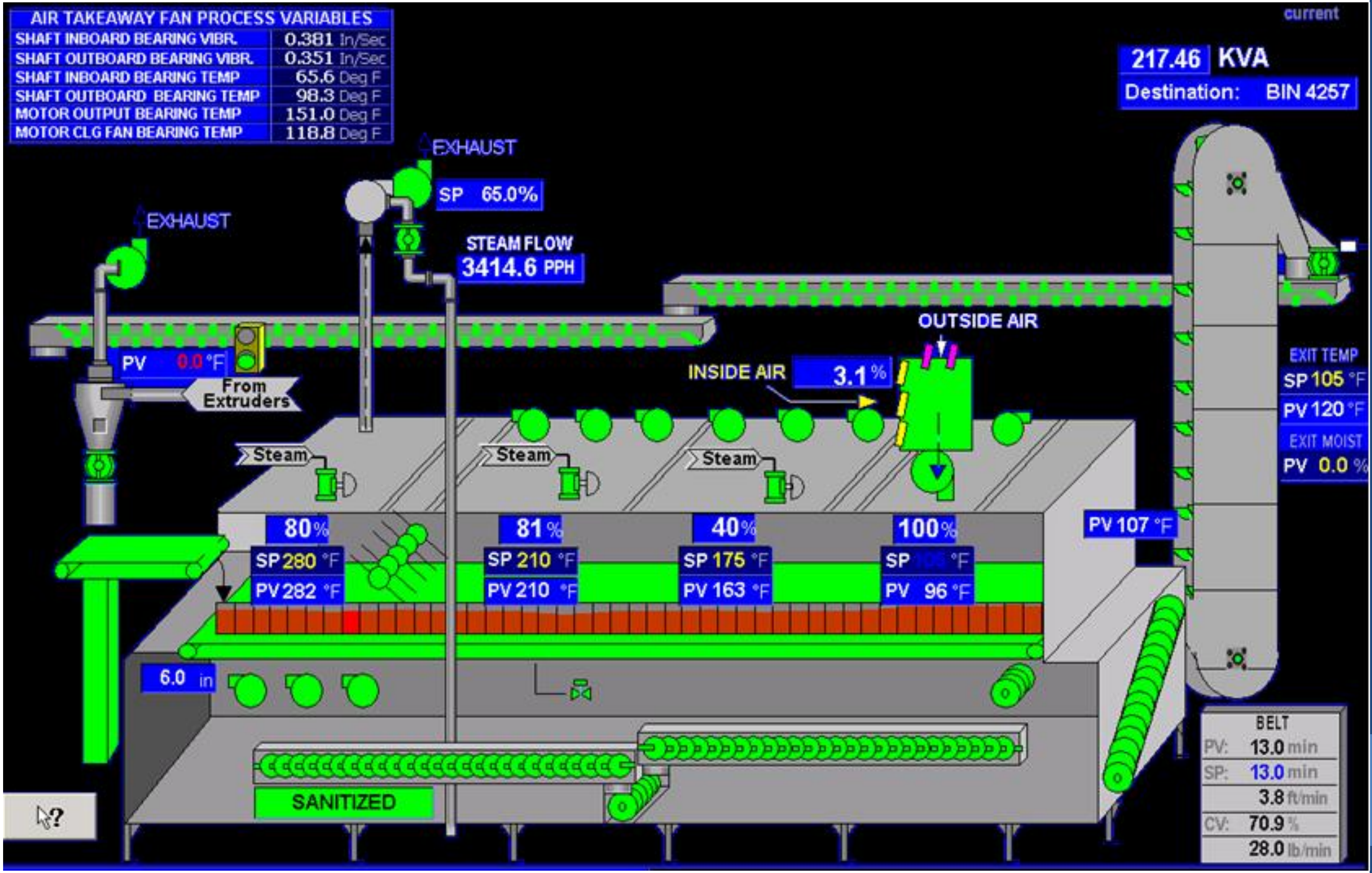
- **Stages:**
  - **Concrete Problem Definition**
  - **System Definition**
  - **Initial Brainstorming**
  - **Osborn’s Checklist**
  - **Refining of Ideas for Concept Selection**

System Definition – Dryer 3



Nestle Purina iFix Interface

Comparison To Dryer 1



Nestle Purina iFix Interface

Comparison Info

- **Dryer 3**
  - **4.6 inch bed depth**
  - **4009.3 pound per hour steam flow rate**
- **Dryer 1**
  - **6 inch bed depth**
  - **3414.6 pound per hour steam flow rate**
- **35% less efficient**

Dryer Efficiency Index = bed depth per steam flow rate

Index of Dryer 3

$$\frac{4.6}{4009.3}(1000) = 1.14733$$

Index of Dryer 1

$$\frac{6}{3414.6}(1000) = 1.7516$$

Percent Difference = 34.7%

Initial Brainstorming

1) Rebuild Steam Traps
2) Insulation
3) Boiler Changes
4) Fuel for Boiler
5) Steam properties
6) Dryer Fuel
7) Steam system
8) Product
9) Dryer Air Flow
10) Dryer size

Osborn's Checklist

Ideas	Adapt	Modify	Magnify	Minify	Substitute	Rearrange	Combine
Rebuild Steam Traps	Buy new steam traps (Industrial Automation Services)	Eliminate need for steam traps	More Steam Traps	Less, more effective steam traps	New steam trap design	Rework how dryer uses steam	
Insulate	Performance contracting insulators, new insulation for steam travel	Insulate entire steam travel distance	More Insulation	Different Insulation			
Boiler	Look at efficiency of a new boiler	Modify boiler piping	More boiler production	Less boiler use	Look into boiler shut down and start up data	Put small boiler in for dryers	<- less distance steam has to travel
Fuel(Boiler)	Natural gas, coal, No. 6 Fuel	Different boiler fuel source	Run at full capacity for maximum efficiency	Reduce to one boiler from two	Different fuel		Steam system changes
Steam properties	Look at other plants operating conditions	Change steam properties (Latent heat, pressure, density)	Ramp up steam energy	Minimize steam energy	Change steam for natural gas	Max combination of properties to maximize efficiency	

Osborn's Checklist

Ideas	Adapt	Modify	Magnify	Minify	Substitute	Rearrange	Combine
Dryer Fuel	Natural gas conversion	Look into alternative fuels	Max out steam energy transfer	Maximize efficiency to minimize fuel	New steam coil design	Rearrange heat transfer system	
Steam system	Minimize transportation of steam	Eliminate steam	Increase steam capacity to maximize efficiency	Minimize steam use in plant	Substitute out new fuel for dryers	Move boilers	
Product	Look at other plants operational conditions	Only run certain product through dryer 3	Maximize bed depth	Less output from dryer	Run product multiple times through dryer	Change bed arrangement	
Dryer Air Flow	Analyze air flow	Maximize heat transfer	Minimize fan speed	Increase air flow for dryer air	Pull in fresh air in between sections	Dry air between sections	
Dryer size	Buy new dryer	Maximize product bed depth	Increase bed surface to decrease depth	Decrease bed surface area to maximize air flow	New machine to dry product		

Analytical Hierarchy Process

Judgment of Importance	Numerical Rating
Extremely more important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

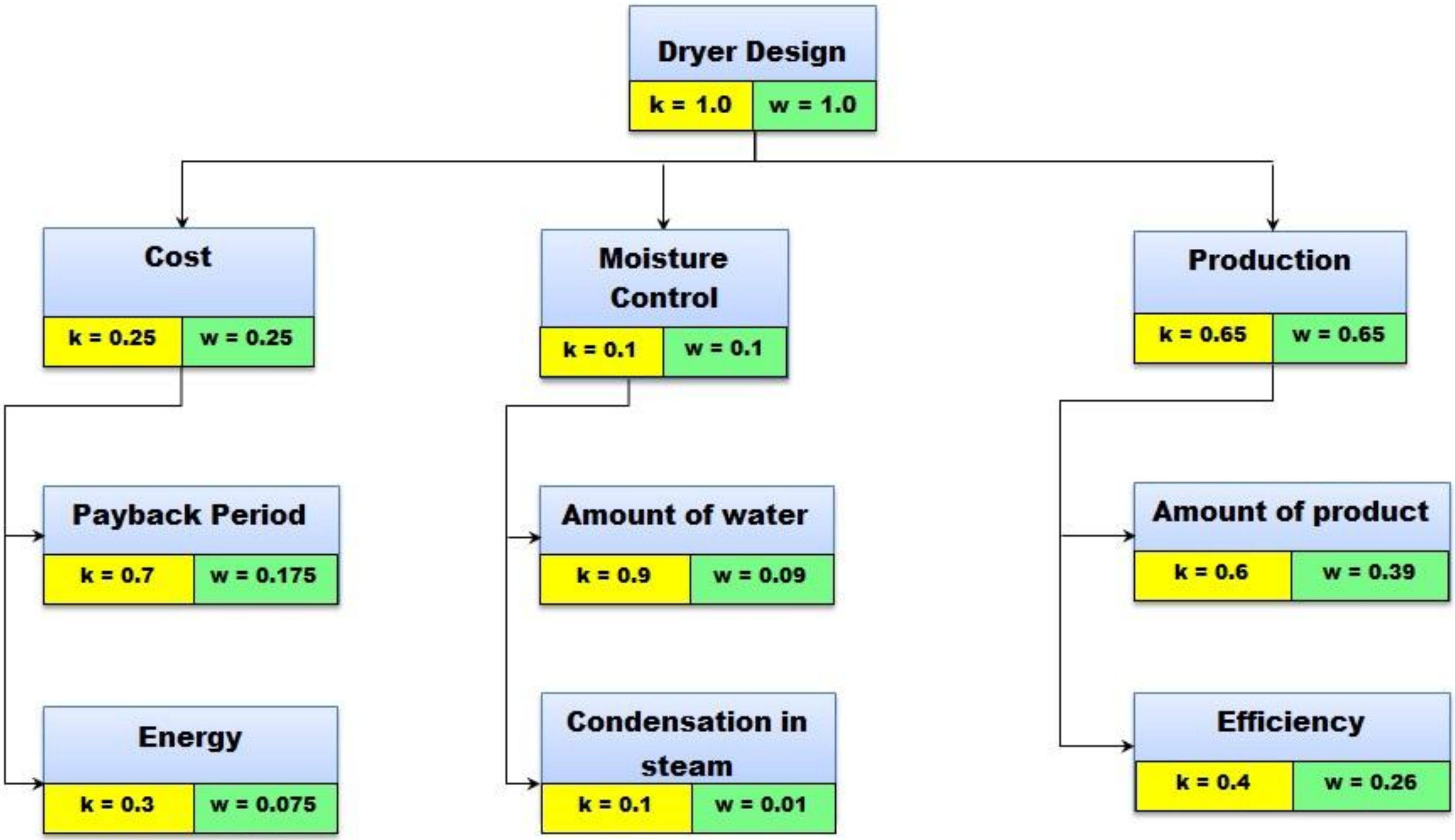
Pairwise Comparison Matrix

	Cost	Moisture Control	Production
Cost	1	3	1/5
Moisture Control	1/3	1	1/5
Production	5	5	1
Total	19/3	9	7/5

Normalized Importance and Overall Importance

	Cost	Moisture Control	Production	Overall Importance
Cost	0.158	0.333	0.143	0.211
Moisture Control	0.053	0.111	0.143	0.102
Production	0.789	0.556	0.714	0.686

Weighted Criteria Tree



Decision Matrix

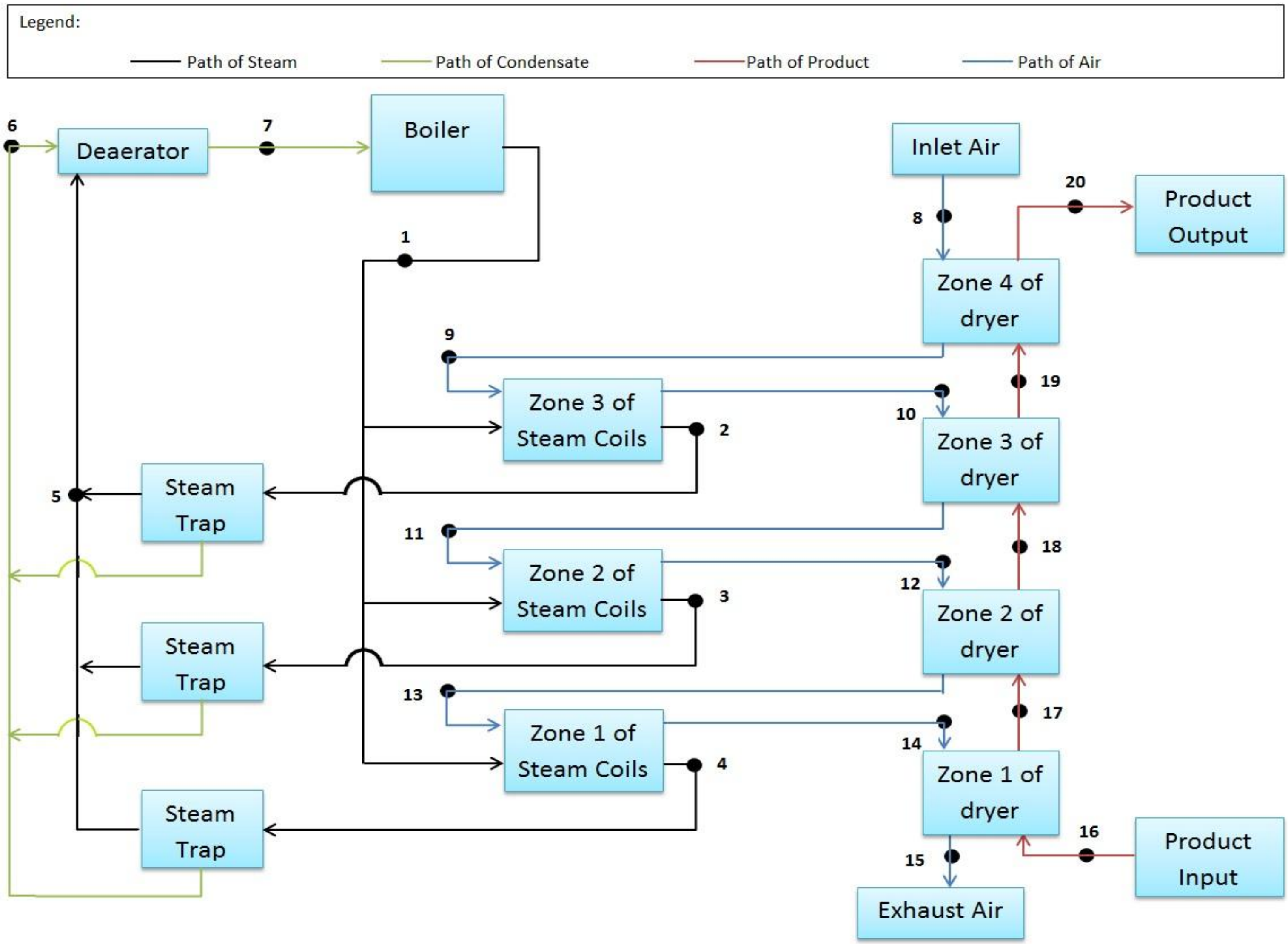
	Cost		Moisture Control		Production		
	Value	Normalized Value	Value	Normalized Value	Value	Normalized Value	Total
Change steam properties. (Latent heat, pressure, density, etc.)	9	1.899	7	0.714	8	5.488	8.101
Analyze air flow	10	2.11	5	0.51	7	4.802	7.422
Pull in fresh air between section	7	1.477	5	0.51	7	4.802	6.789
Natural Gas Conversion	1	0.211	10	1.02	8	5.488	6.719
New steam coil design	7	1.477	8	0.816	6	4.116	6.409
Dry air between sections	5	1.055	5	0.51	7	4.802	6.367
New steam trap design	7	1.477	5	0.51	6	4.116	6.103
Buy new steam traps	3	0.633	6	0.612	6	4.116	5.361
Look at other plants operating conditions	10	2.11	4	0.408	3	2.058	4.576
Increase bed surface area so depth will decrease	3	0.633	4	0.408	5	3.43	4.471
Performance contracting insulators, new insulation for steam travel	5	1.055	5	0.51	4	2.744	4.309
Minimize transportation of steam	4	0.844	6	0.612	4	2.744	4.2
Run product multiple times through dryer	1	0.211	5	0.51	3	2.058	2.779
Scale 1-10	10 = best, 1 = worst						

Engineering Analysis

- Convert to a natural gas dryer

- Analyze the existing system
  - Air
  - Steam

Thermodynamic Model



Collected properties for each point defined in Model

Point	Description	Property	Others
1	Stream inlet	T = 273F P = 50psi	should be saturated steam
2	zone 3 steam outlet	T = 230F	
3	zone 2 steam outlet	No Data Collected	
4	zone1 steam outlet	No Data Collected	
5	steam trap outlet	T = 100F	
6	condensate return	T = 180F	
7	Boiler inlet	P = 148psi	efficiency: 84.09%
8	Air inlet	P = atmospheric T = 139F	
9	zone 4 air outlet	T = 63F	
10	zone 3 air inlet	T = 187F	
11	zone 3 air outlet	T = 184F	
12	zone 2 air inlet	T = 226F	
13	zone 2 air outlet	T = 178F	
14	zone 1 air inlet	T = 216F	
15	exhaust	P = atmospheric	standard pressure
16	product inlet (cyclone exit)	T = 150F	22% moisture content
17	zone 1 (inlet)	T = 215F	22% moisture content
18	zone 2 (inlet)	T = 200F	15.5% moisture content
19	zone 3(inlet)	T = 180F	11.5% moisture content
20	zone 4 (inlet)/ dryer outlet	T = 100F	9% moisture content

Natural Gas Conversion

- **Aeroglide Dryers**
  - **Introduction**
  - **Operation**
- **Work with Clinton, IA plant**
- **High Efficiency**

http://www.aeroglide.com/snack-dryers-roasters-ovens.php

Natural Gas Analysis

- Using thermodynamics
  - Efficiency
  - Flow rate
  - Relative humidity (moisture control)
  - Compare to current dryers
    - Throughput
    - Improvement of efficiency

- Heat Transfer
  - Estimate amount of heat transfer

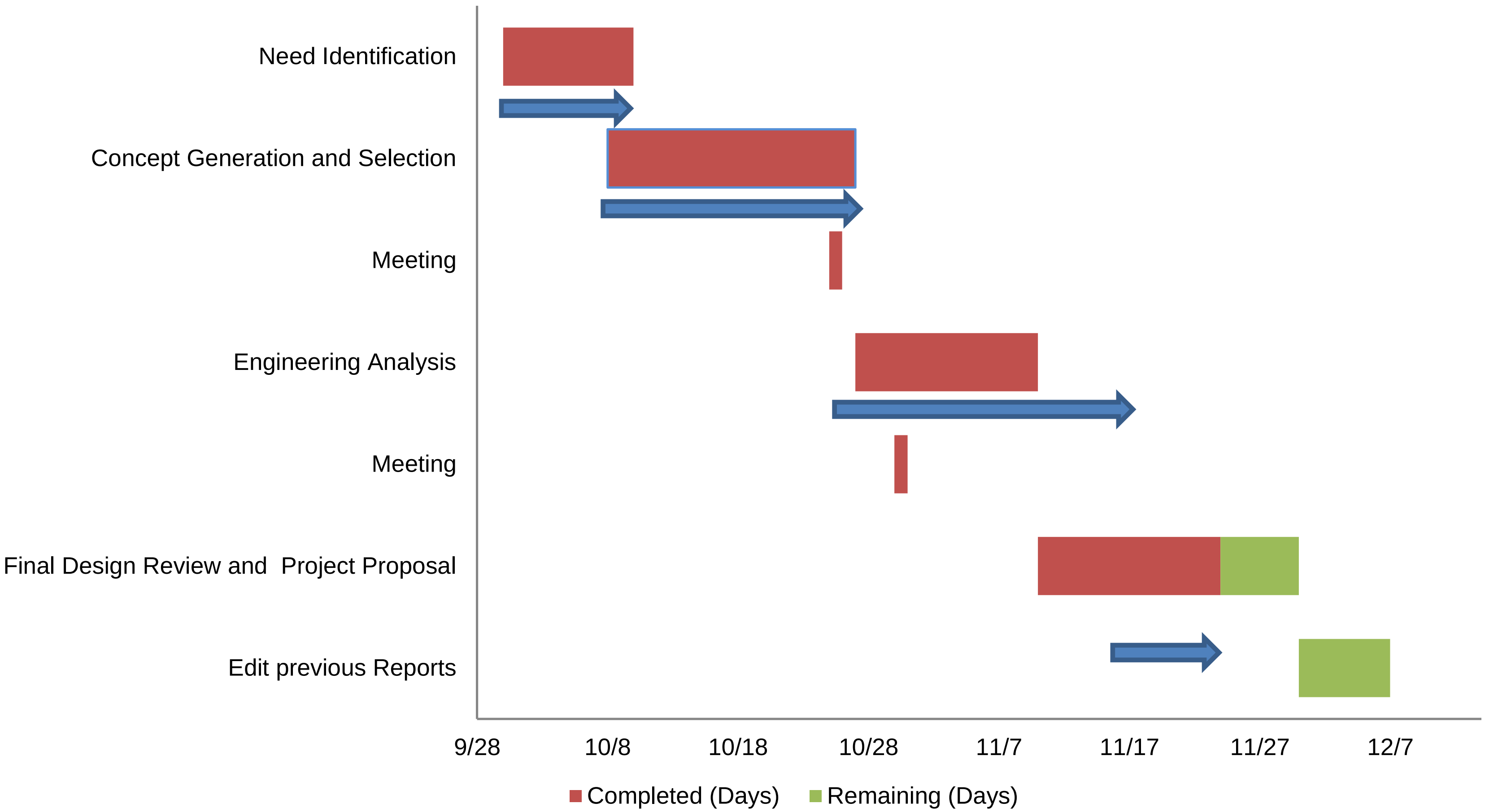
Steam / Air Analysis

- Thermodynamics
  - Global/entire system
- Heat Transfer
  - Local components
- Fluid Dynamics
  - Pipe friction
  - losses

Cost Analysis

- Natural Gas Conversion
  - Initial investments
  - Gas usage
  - Payback period
  - Efficiency
- Steam / Air
  - Modification costs
    - Steam traps, insulation, piping
- Boiler
  - Efficiency (steam production / fuel costs)

Updated Gantt Chart



Proposal

- **Design and plan the conversion of steam dryer 3 to a natural gas dryer**

- **Perform thermodynamic analysis on new design to determine efficiency benefit**

- **Perform cost/benefit analysis on new design**

Conclusion

- Review of problem statement
- Review of concept generation
- Review of engineering analysis
- Planned analysis for each idea
- Cost analysis / economics

References

- **Clint Chadwick**
  - **Environmental Coordinator**
  - **Nestle Purina Pet Care, Flagstaff, AZ**
- **Chad Girvin**
  - **Processing Maintenance Team Leader**
  - **Nestle Purina Pet Care, Flagstaff, AZ**
- **Buhler Aeroglide Natural Gas Dryer**
  - http://www.aeroglide.com/snack-dryers-roasters-ovens.php