



# Biofuel Production & Implementation Feasibility Study

A Proposal for Calvin College

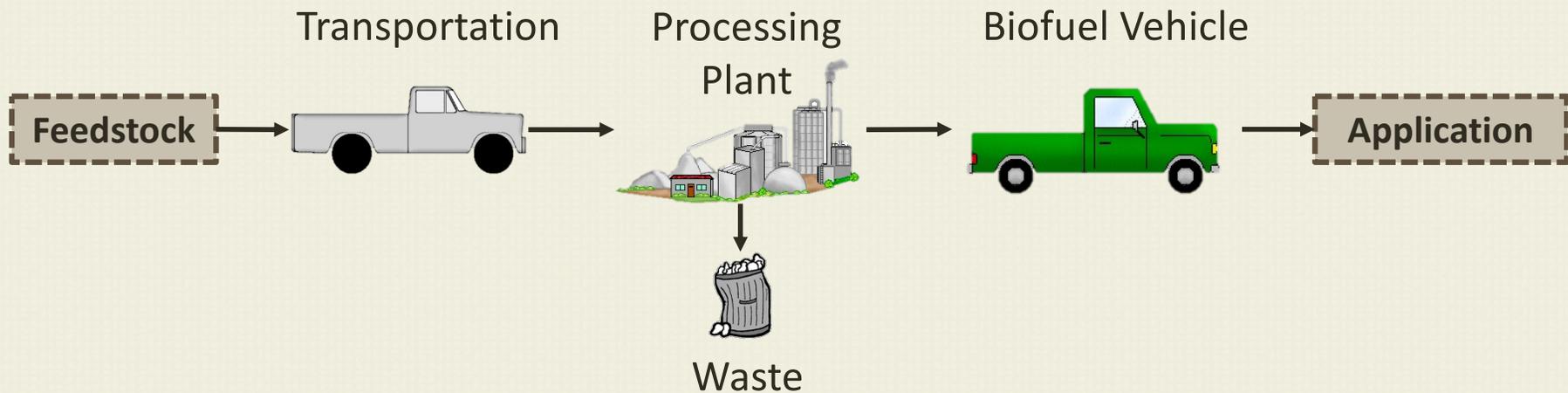
Presented By: Engineering 333 & Business 380

12/09/2013



# Project Objective

What would it take to operate a biofuel vehicle using only on-campus resources?





# Project Segmentation

## Technical Feasibility

- Fuel Selection
- Vehicle Selection
- Facilities Selection
- Future Planning

## Messaging & Communication

- Students
- Prospective Students
- Faculty/Staff
- Alumni/Community
- Donors
- Decision-Makers



# Resources

- Prof. Matthew Heun – Engineering Department
- Prof. Thomas Betts – Business Department
- Mr. Phil Beezhold – Physical Plant Director
- Mr. David LaGrand – Local Biofuel Producer
- Mr. Geoffrey Van Berkel – Physical Plant Grounds
- Mr. Rick Balfor – Dining Services
- Mr. Rich Huisman – Chemistry Department
- Mr. Henry Kingsma – Physical Plant Recycling



# Fuel Production and Feedstock

Presented by: Claire Philippi

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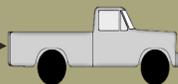


# Fuel?

# Processing?

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Feedstock



Vehicle Application

( 6 )



# Fuel Options



Image source: nationalgeographic.com

Methane



Image Source: baconsrebellion.com

Ethanol



Image Source: biodieselchemist.webs.com

Biodiesel



Image Source: zombiehunters.org/wiki

Vegetable Oil





# Fuel Quality

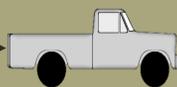
Fuel Clarity



Acidity



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Vehicle Application

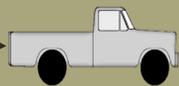


# Filtration Methods



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Vehicle Application



# Costs

- The Upfront Component Costs:

- Centrifuge and heating source: \$1494
- Settling tanks: \$ 428
- Filter and screens: \$ 50

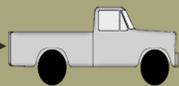
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**Total: \$1972**

- Monthly Operating Costs:

- Filters & Screens \$ 4
- Heat \$ 10

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# Facilities & Infrastructure

Presented By: Karl Bratt



# Where to Process?

# How to Process?

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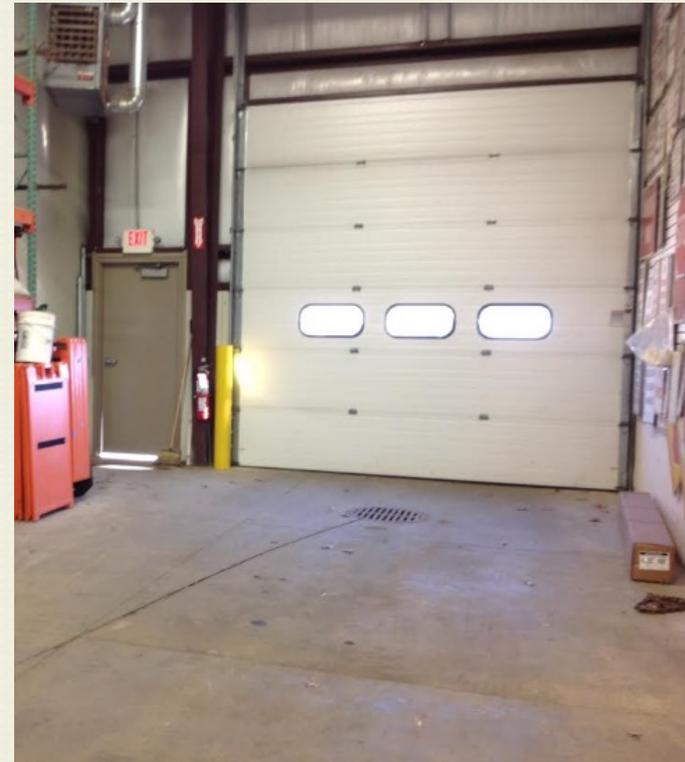


Vehicle Application

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# WVO Processing Location Physical Plant Warehouse



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Vehicle Application



# Shelving Industrial Racking System



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Vehicle Application

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# Heating Existing Heater & Heating Tape



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Vehicle Application

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# WVO Storage



Image Source: [www.automotivetools.com/Liquidynamics](http://www.automotivetools.com/Liquidynamics)



Image Source: [www.disasterstuff.com](http://www.disasterstuff.com)



Image Source: [www.amazon.com](http://www.amazon.com)

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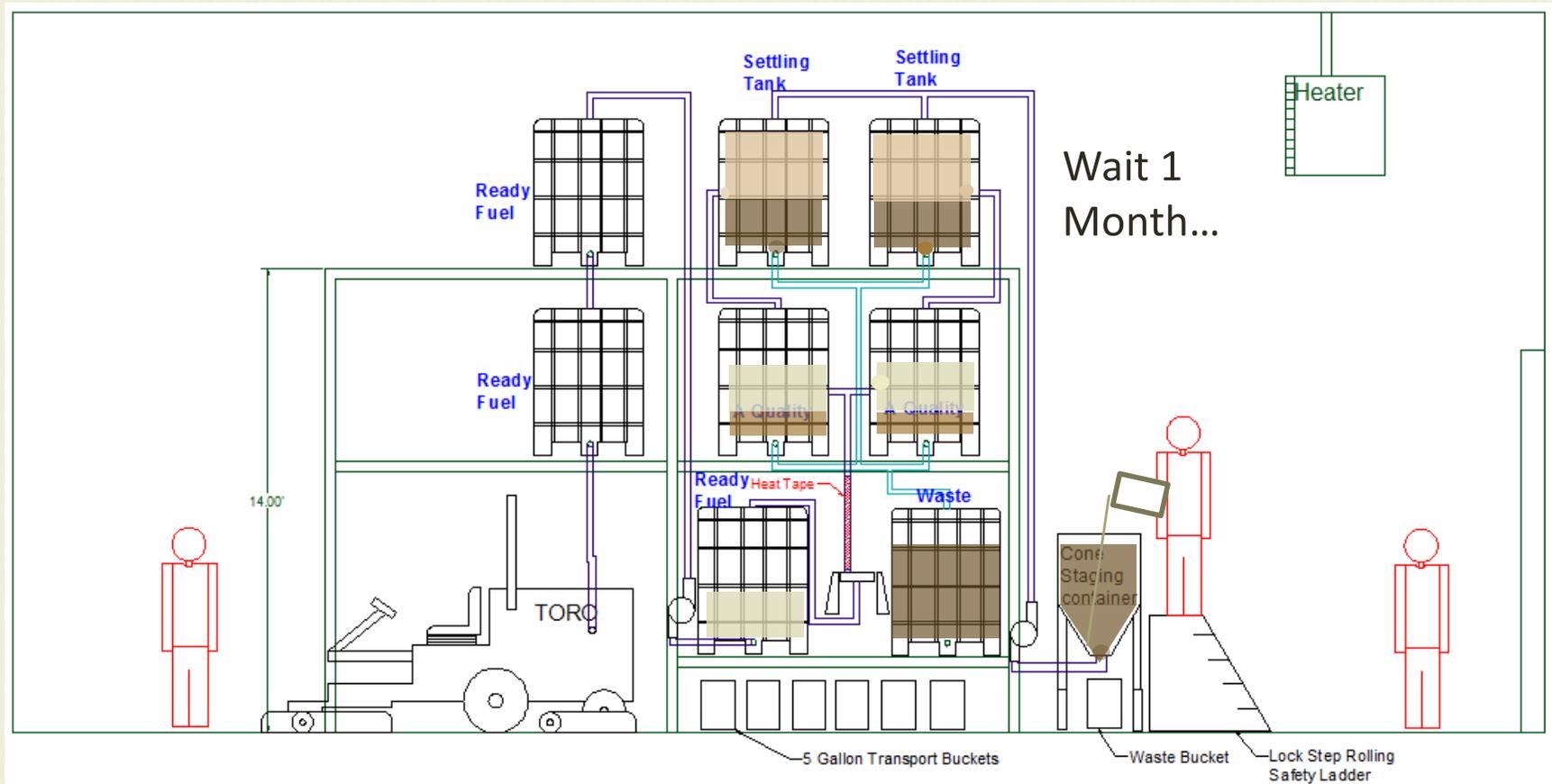


Vehicle Application



# Process Design

## Rigid, Parallel System



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Vehicle Application

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# Raw WVO Transportation Recycling Truck



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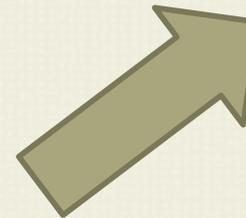
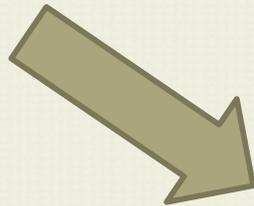


Vehicle Application

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# Compost



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Vehicle Application



# Costs

- Upfront Component Costs:

- Pipes Pipe Connectors: \$ 1,200
- Calvin Physical Plant labor: \$ 600
- Valves & Actuators: \$ 428
- Electronic Components: \$ 185

---

**Total: \$2,413**

- Monthly Operating Costs:

- Student Labor (Year 1): \$ 450
- Student Labor (Year 2): \$ 150

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# A Biofuel Vehicle

Presented by: Mike Houtman

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# What Vehicle?

# How to Convert?

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Vehicle Application

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# WVO Conversion

WVO criteria to be met:

Diesel Engine



Image source: Dieseltronics

WVO Purge



Image source: WVO Designs

5 Microns



Image source: Greasecar.com

160°F



Image source: Glow Shift Direct

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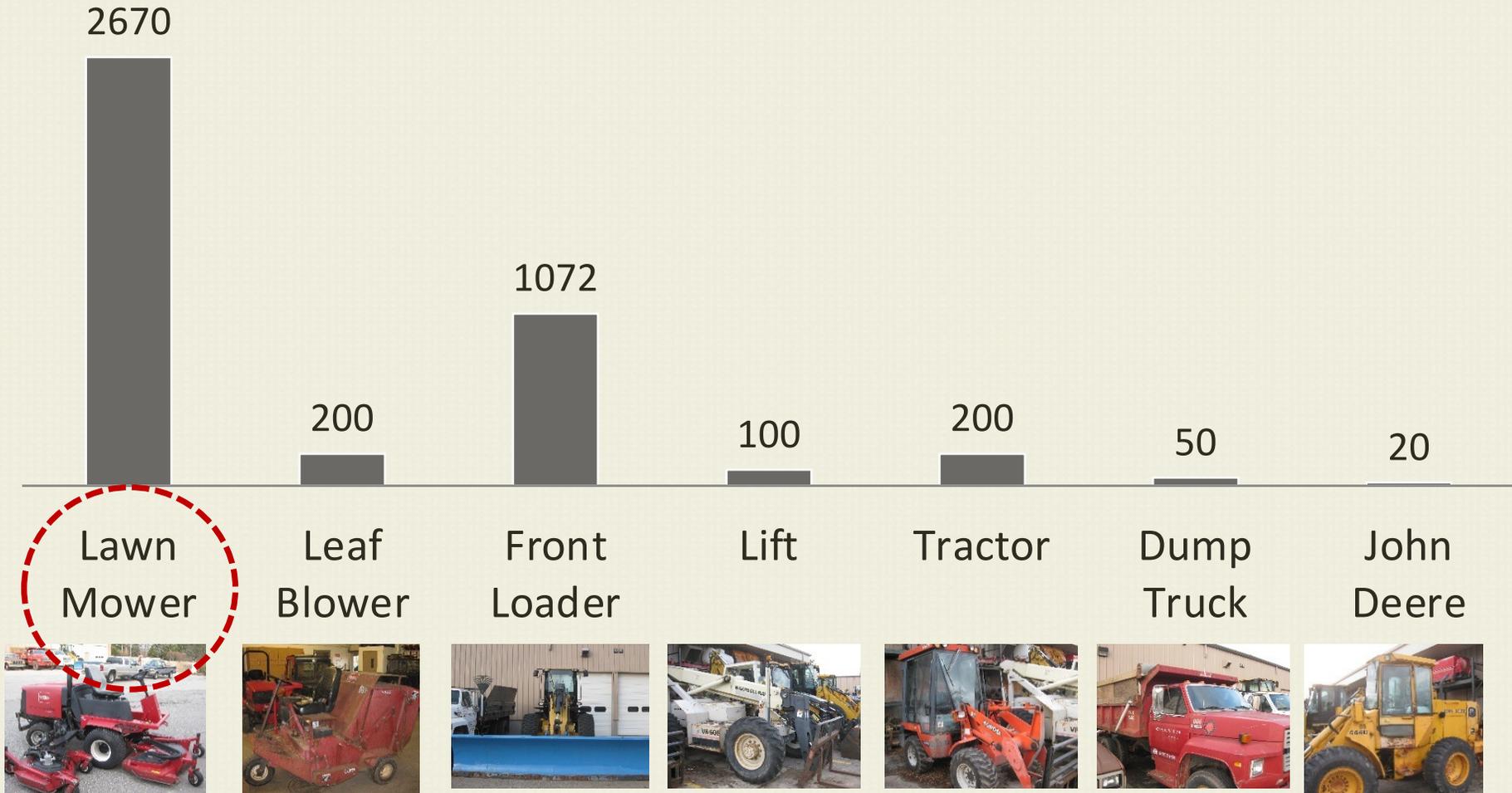
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Vehicle Application



# Vehicle Yearly Usage (hours)



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# 2006 Toro *GROUNDMASTER* 4000-D



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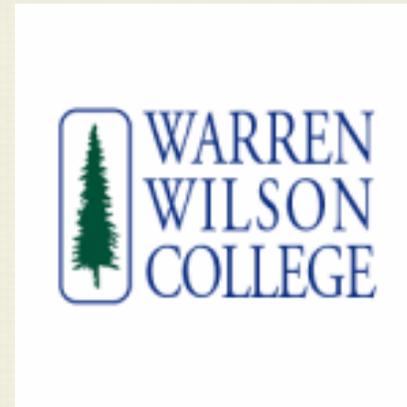
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# Previous Experience



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# Vendors



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# Kits Available

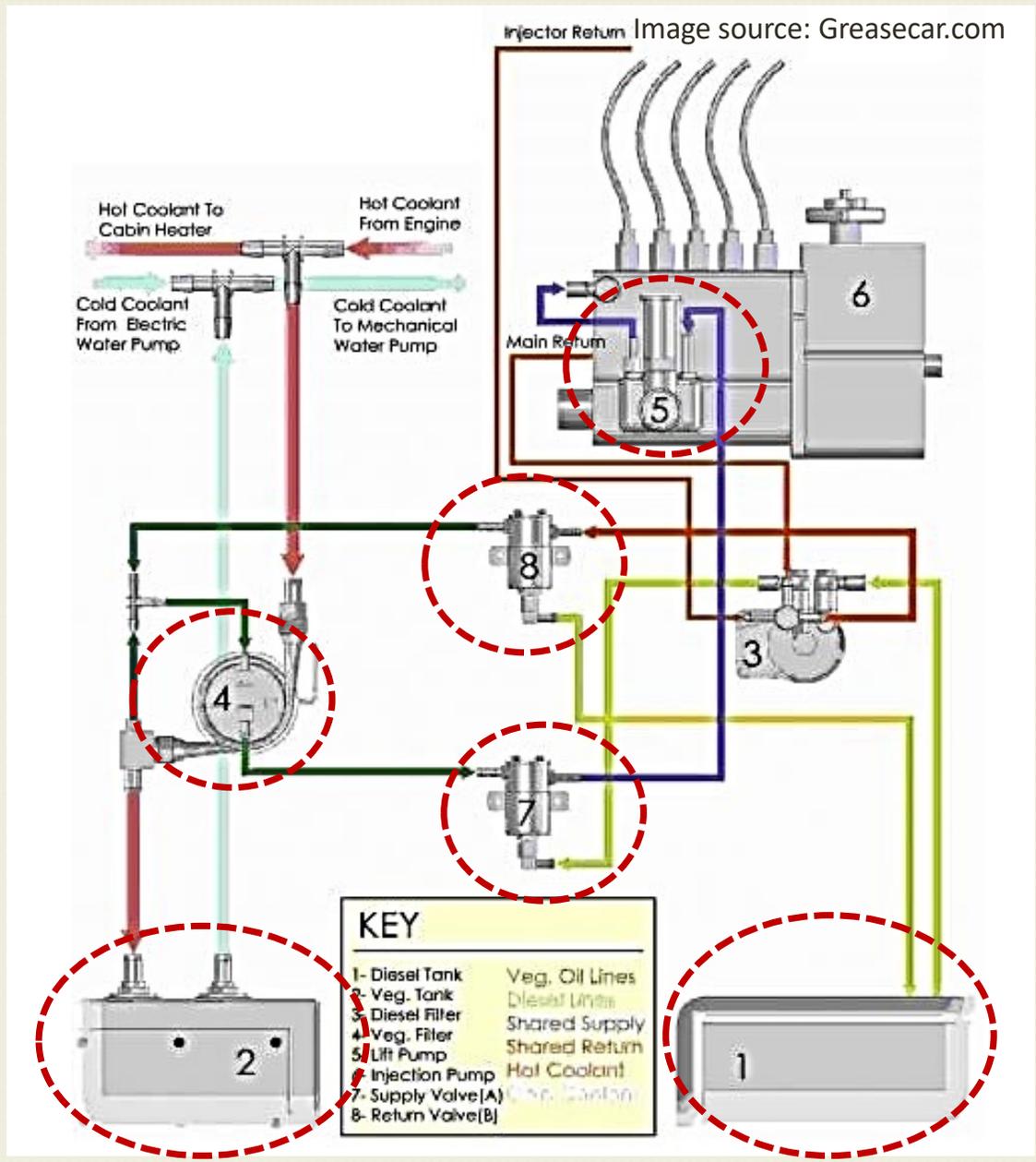


Image source: Greasecar.com

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# WVO Tank Location



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# Controller Location



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# Costs

- The purchased equipment costs of this system derive from:
  - Greasecar WVO kit: \$1595
  - Greasecar “Co-Pilot” controller: \$ 300
  - Calvin Physical Plant labor: \$ 360
  - Insulating tank cover: \$ 40

---

**Total: \$2295**





# Long-Term Planning

Presented by Brandon Koster

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Mower Maintenance?  
Possible Expansion?  
CERF Involvement?  
Educational Outcomes?

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# Fuel Injector Maintenance



Image Source: [www.standardbrand.com](http://www.standardbrand.com)



Image Source [ecx.images-amazon.com](http://ecx.images-amazon.com)

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# Fuel Filter Maintenance



Image Source: [www.vw-resource.com](http://www.vw-resource.com)

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# Engine Oil Analysis



Image Source: [www.rockingsconsulting.com](http://www.rockingsconsulting.com)

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# Testing Period



Image Source : bestclipartblog.com

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# Additional Vehicle Options

## Campus Safety Vehicle



Image Source: vimeo.com

## Transportation Van



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# New Vehicle Selection

## 2002-2006 Dodge Sprinter Van



<http://mbgtown.files.wordpress.com/2010/10/2008-sprinter-passenger-van-0061.jpg>



<http://www.moibibiki.com/images/dodge-sprinter-4.jpg>

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# New Feedstock Sources



<http://1.bp.blogspot.com/>



[http://farm4.static.flickr.com/3201/2409592844\\_f382ca64a7\\_o.jpg](http://farm4.static.flickr.com/3201/2409592844_f382ca64a7_o.jpg)

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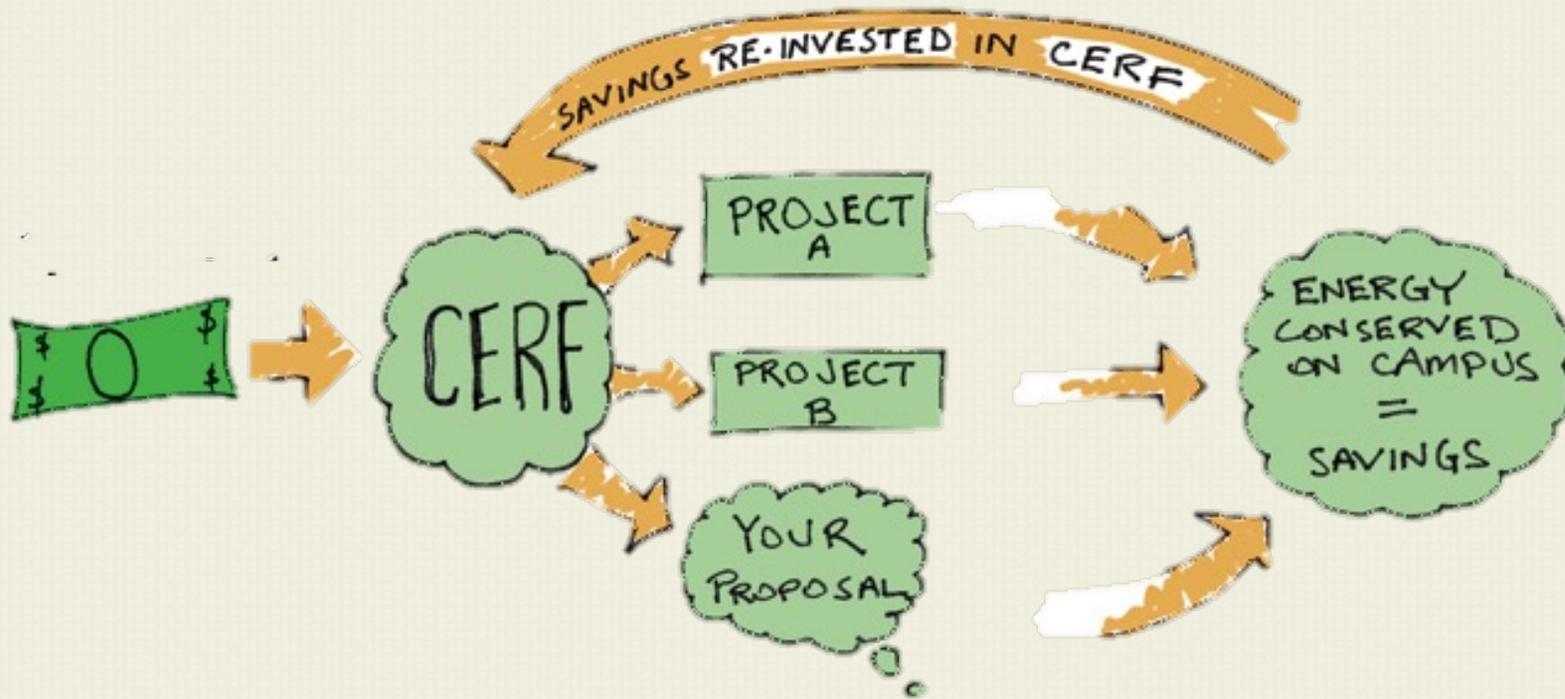


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# CERF Integration: Capital Funding



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# CERF Integration: Internship Program



[http://www.chamaschools.org/wp-content/uploads/CLIPART\\_OF\\_32162\\_SMJPG\\_2.jpg](http://www.chamaschools.org/wp-content/uploads/CLIPART_OF_32162_SMJPG_2.jpg)

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# Educational Integration

Engineering  
101

Fridays at  
Calvin

Annual  
Seminars

Prelude

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# Possible Senior Design Project: Automating the Production System



Two Electrical  
Concentrations

One  
Mechanical  
Concentration

One Chemical  
Concentration

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# Costs

- The monthly ongoing maintenance costs:
  - 1 hour Physical Plant Mechanic Time: \$ 45
  - Fuel Injector Additive: \$ 16
  - Fuel Filter: \$ 15
  - CERF Intern \$ 180

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**Total: \$221/month**

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# Upfront Capital Costs

- Fuel Processing Costs: \$ 1,972
- Vehicle Conversion Costs: \$ 2,295
- Infrastructure Costs: \$ 2,413

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**Total: \$6,680**

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# Monthly Operating Costs

- Fuel Processing Costs: \$ 14
- Vehicle Conversion Costs: \$ 221
- Infrastructure Costs: \$ 150

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**Total: \$ 385**

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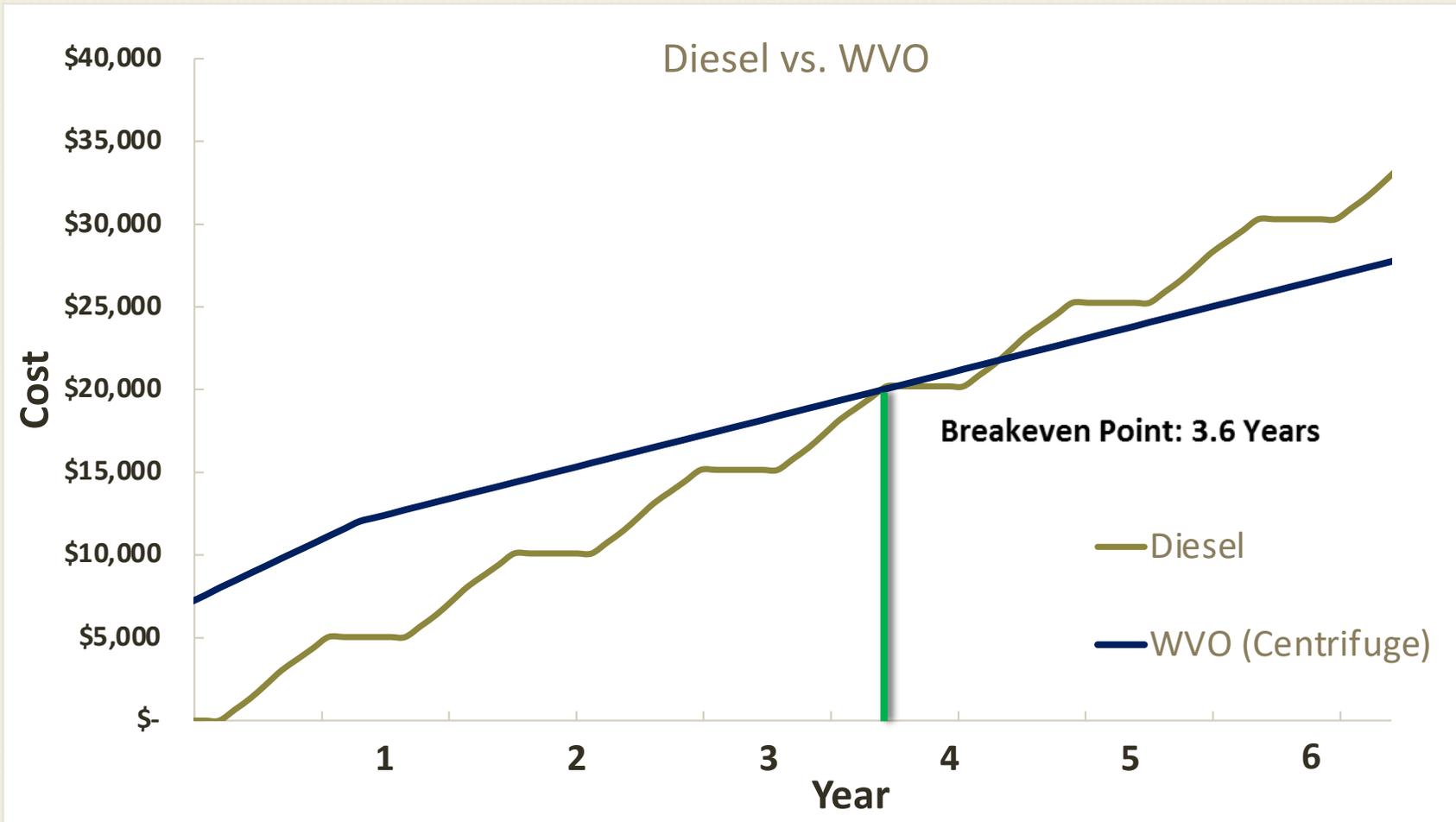


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# Total Cost Analysis Breakeven (w/ Student Labor)



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# Proposed Timeline



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# Feasibility

- Practically Feasible?
- Economically Feasibility?
- Environmentally Feasibility?

**YES**

**YES**

**YES**





We recommend that Calvin operate one mower on WVO beginning April 2015.

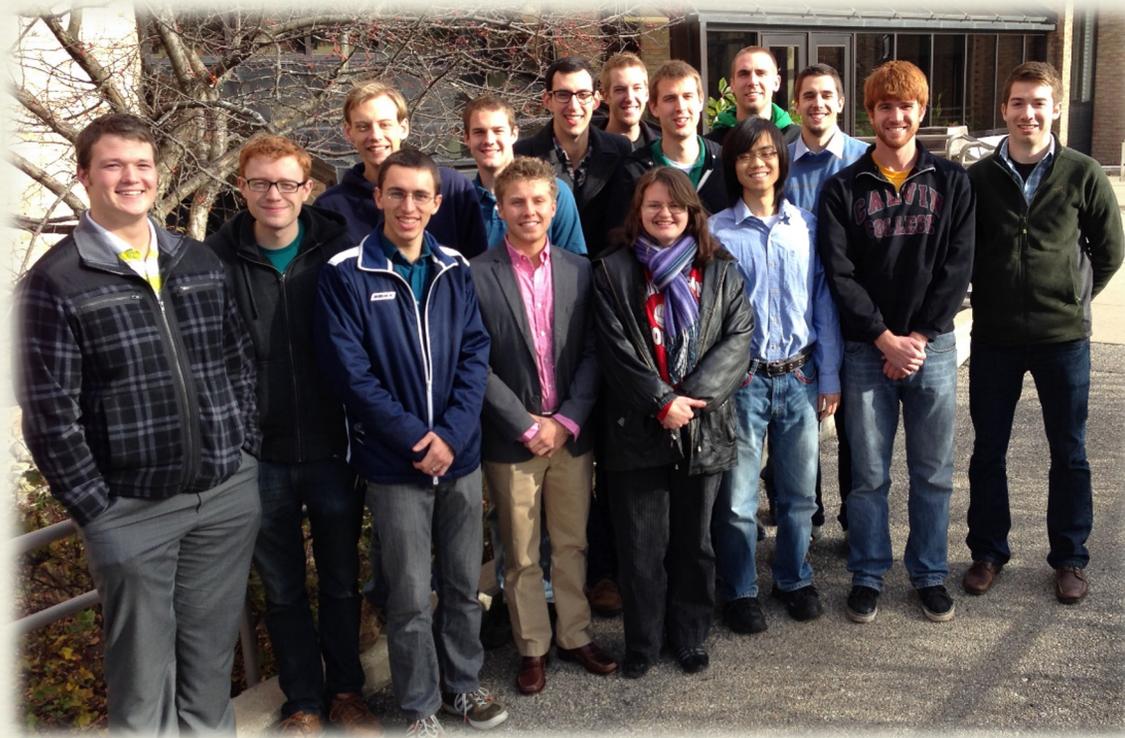


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Thank you for your time...

Questions?



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# Appendix

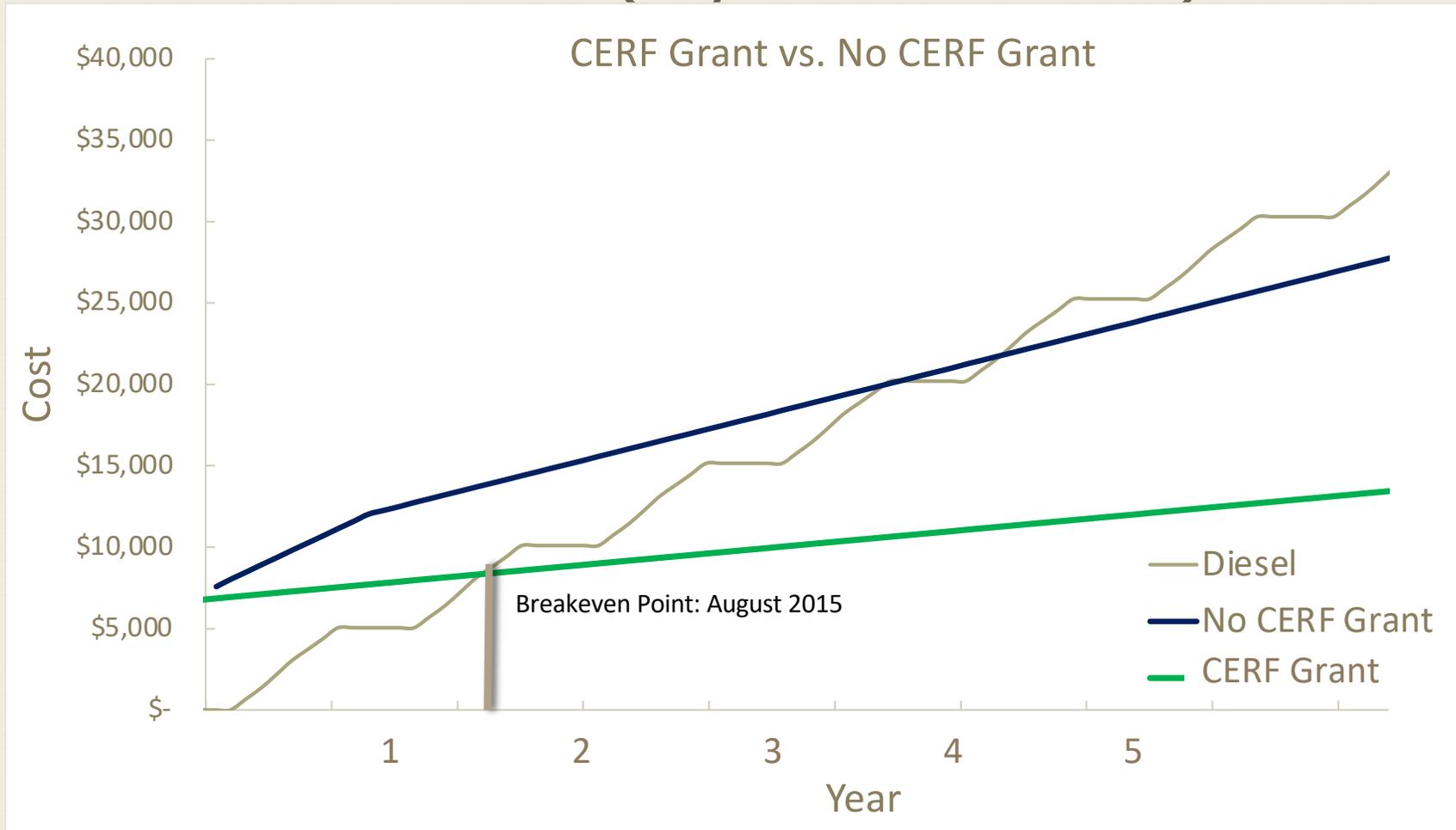


# Operating Procedure

- WVO temperature
  - The system must be started on diesel and the “Co-Pilot” will assist the operator in the fuel switch over
  - Process takes approximately 5 minutes
- System flush
  - System must be flushed with diesel before final shut-down
  - Process takes less than 1 minute
- Fuel Usage
  - The tank must be routinely at capacity to prevent air in the lines
  - The tank must not be stored with WVO throughout winter
  - The tank must be cleaned and inspected to prevent polymerization
  - The fuel must be treated with additives to prevent bacterial growth



# Total Cost Analysis Breakeven (w/ CERF Grant)



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# Tank Insulation

**FREE UPS Ground Shipping** on all orders of \$50 or more! **EXPEDITED SHIPPING ALSO AVAILABLE**  
 more than 400,000 unique items in stock

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Search results may not be a precise match for product brands

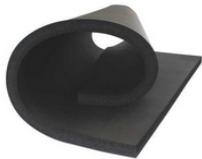
All Categories [About Us](#) [Contact Us](#) [Using Our Site](#) [Open Account Billing](#) [Catalog Request](#) [Questions/Feedback](#) [Resource Den](#)

## Flexible Therma-Cel Polyolefin Pipe Insulation

THERMACEL

[SEE MORE >>> Pipe Insulation](#)

**CHECK OUT TODAY'S HOLIDAY OFFER.**  
click for details >>



Description : For Use On : Pipe

Narrow by

Item **Insulation Sheet**

Insulation Sheet

Type **Flexible**

Flexible

Insulation Nominal I.D.

3/8" 1/2" 5/8" 3/4" 7/8" 1-1/8" 1-3/8" 1-5/8" 2" 2-1/8" 2-3/8" 2-5/8" 4-1/2"

Copper Tube Size (Nom. I.D. Plumbing)

1/4" 3/8" 1/2" 5/8" 3/4" 1" 1-1/4" 1-1/2" 2-1/2"

Iron Pipe Nominal Size

1/8" 3/8" 1/2" 3/4" 1" 1-1/4" 1-1/2" 2" 4"

Length **4 ft.**

4 ft. 8 ft.

Wall Thickness **1/2"**

3/8" 1/2" 3/4" 1"

Temp. Range **-330 to 210 Degrees F**

-330 to 210 Degrees F

Color **Black**

Approx. "R" Factor **2**

2

\* Products that meet your criteria are shown in table below.

Material of Construction **Elastomeric**

Elastomeric Polyethylene

Copper Tube Size (O.D. HVAC/R)

3/8" 1/2" 5/8" 3/4" 7/8" 1-1/8" 1-3/8" 1-5/8" 2-1/8" 2-5/8"

Mfr.# **6ZRFG3X4048**

6ZRFG3X4048

[CLEAR SELECTIONS/RESET TABLE >>](#)

Click for images of all products

Product Description :

Insulation Sheet, Flexible, Sheet Size 36 In x 48 In, Length 4 ft., Temp. Range -330 to 210 Degrees F, Color Black, Material of Construction Elastomeric  
Sheet Size : 36" x 48", Width : 36", Agency Compliance : ASTM C-177

### Product Options

Like This Product?

Showing 1 to 1 of 1 (filtered from 31 total)

Item	Type	Insulation Nominal I.D.	Copper Tube Size (Nom. I.D. Plumbing)	Iron Pipe Nominal Size	Length	Wall Thickness	Temp. Range	Color	Approx. "R" Factor	Material of Construction	Copper Tube Size (O.D. HVAC/R)	Mfr.#
Insulation Sheet	Flexible	-	-	-	4 ft.	1/2"	-330 to 210 Degrees F	Black	2	Elastomeric	-	6ZRFG3X4048

**ADD TO CART**

**\$18.35/EA**

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# Yearly Savings

- Fuel savings
  - 1300 gallons of diesel
- Cost savings
  - \$4,000 of purchased diesel



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# Hardware Locations



Image source: Greasecar.com

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[ 60 ]

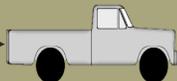


# Temperature Concern



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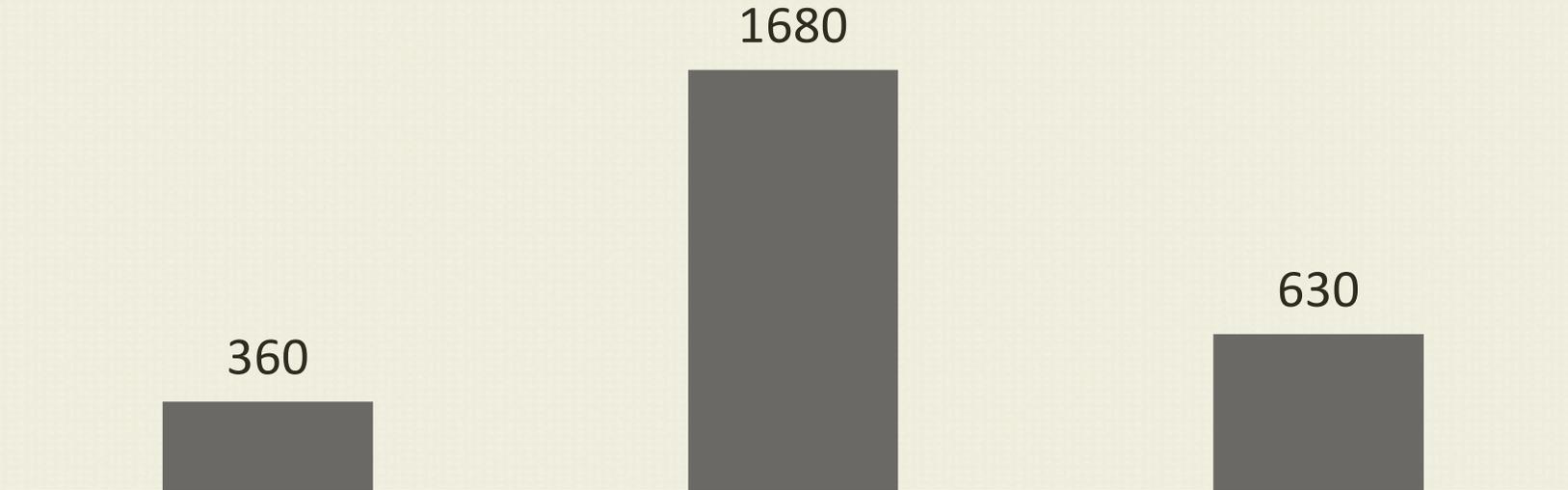
**Vehicle Application**

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# Yearly Lawnmower Usage

(hours/model)



Mower 1 (4700D)

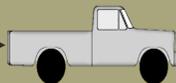
Mowers 2&3 (4000D)

Mower 4 (3280D)



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# Temperature Solution

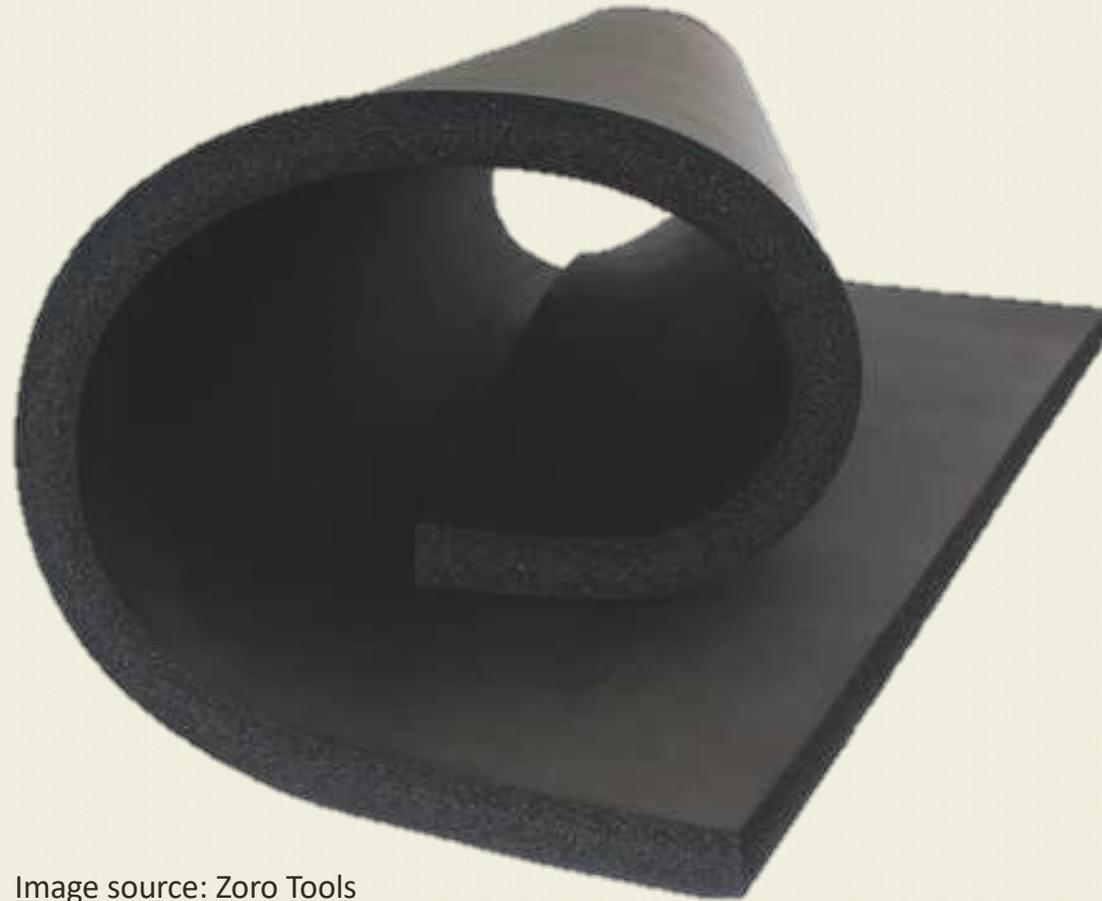
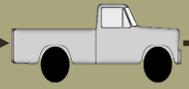


Image source: Zoro Tools

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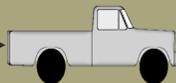


# Controller Location



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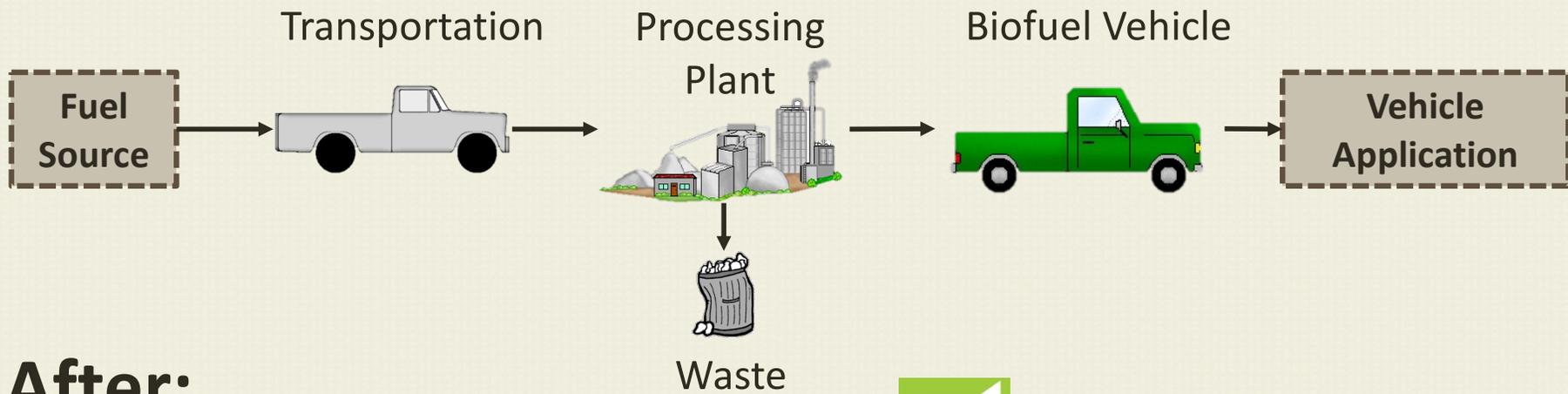
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# Presentation Outline

## Before:



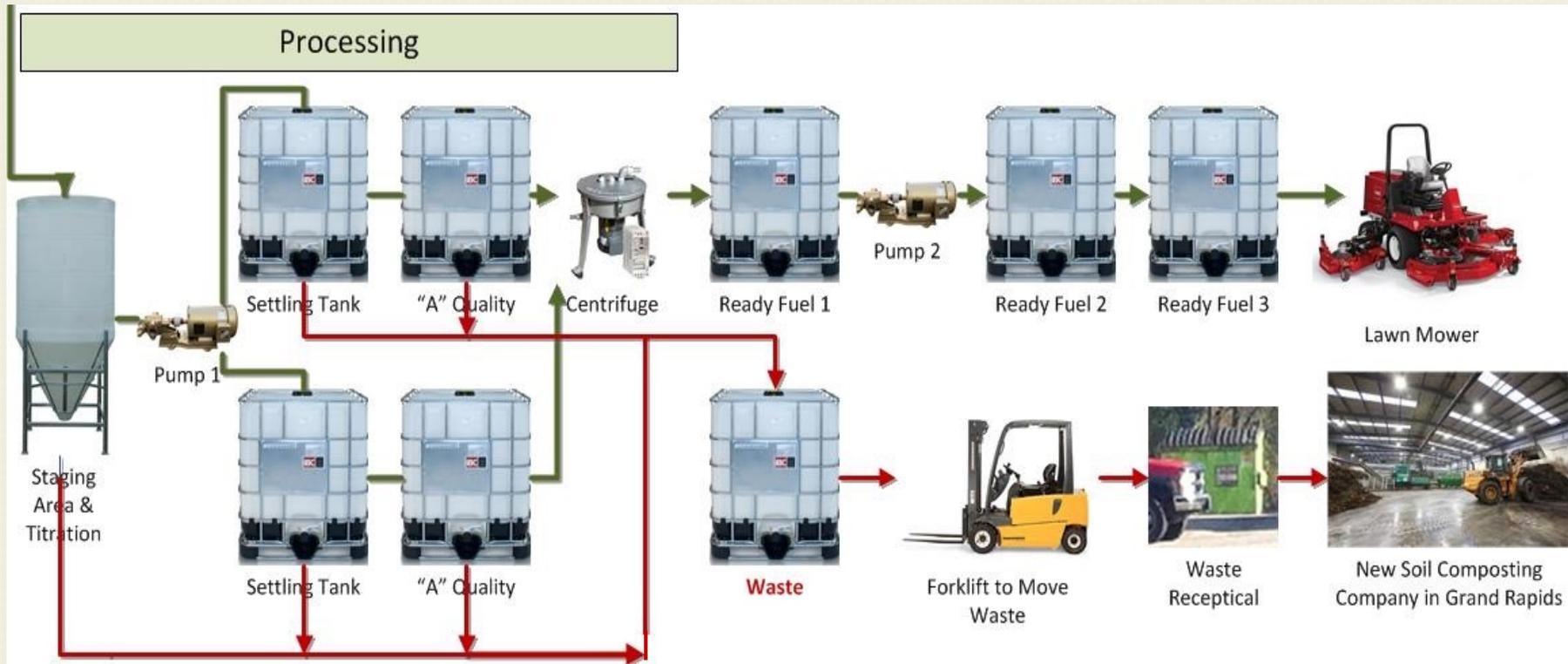
## After:





# Process Design

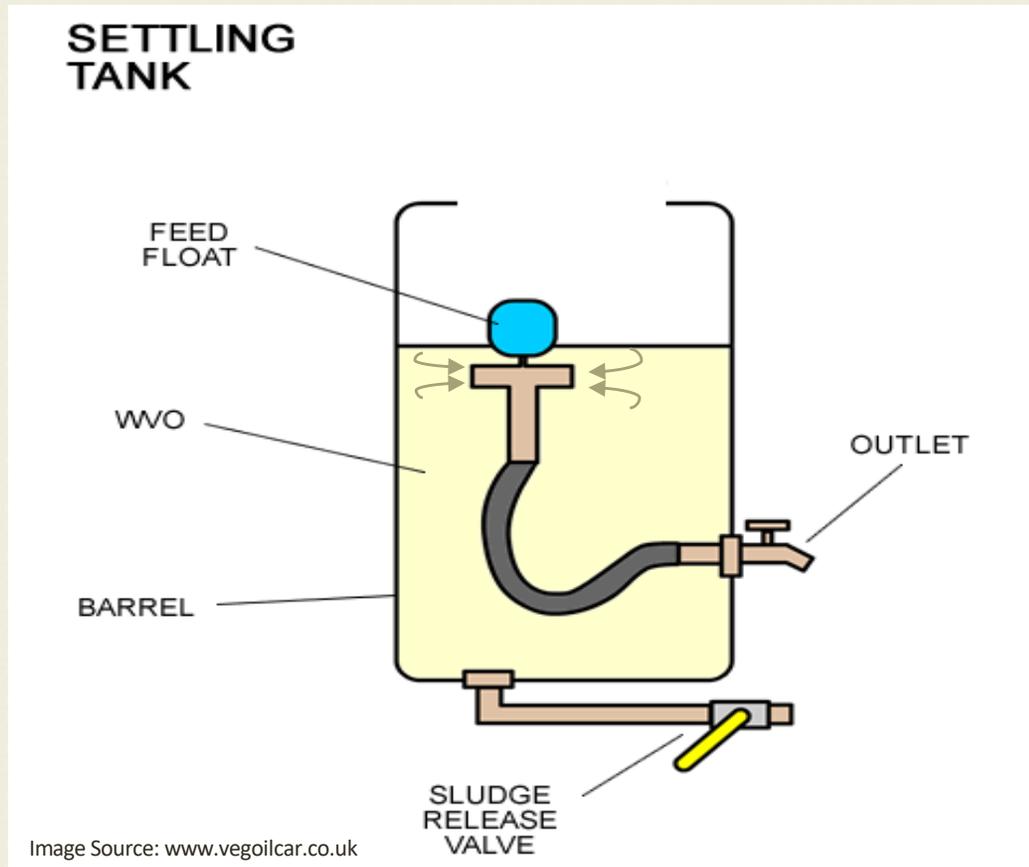
## Rigid, Parallel System





# Tank Dispense

## Two Outlet, Float Dispense



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# Total Upfront Costs = \$6,850

	Vendor	Cost	Quantity	Total Cost
<b>Vehicle Team</b>				
Lawn Mower Kit	Greasecar	\$ 1,895.00	1	\$ 1,895.00
Installation Time	Calvin Physical Plant	\$ 60.00	8	\$ 480.00
<b>Vehicle TOTAL</b>				\$ 2,375.00
<b>Facilities &amp; Infrastructure Team</b>				
Raw Power Centrifuge	WVO Designs	\$ 1,197.00	1	\$ 1,197.00
Centrifuge Bolt-on Heater	WVO Designs	\$ 297.00	1	\$ 297.00
275 gallon IBC Tote	Craigslist	\$ 30.00	8	\$ 240.00
Duda 110 Gallon Cone Tank	DudaDiesel	\$ 188.00	1	\$ 188.00
25gpm Industrial Oil Transfer Pump	WVO Designs	\$ 350.00	2	\$ 700.00
2" PVC Piping (per foot)	Lowes	\$ 2.04	150	\$ 306.00
PVC Schedule 40; 2" Ball Valves	Lowes	\$ 14.85	13	\$ 193.05
Ball Valve Actuator	MegaHobby	\$ 15.50	11	\$ 170.50
Male/ Female Connectors	Lowes	\$ 2.60	7	\$ 18.20
PVC 90 Degree Joints	Lowes	\$ 15.00	12	\$ 180.00
600 Micron EZ Strainer - 55 Gal	Amazon	\$ 50.00	1	\$ 50.00
Heating Tape (\$/ft)	ACE Hardware	\$ 1.67	24	\$ 40.00
Uniseal for 2" Pipe	Tank Depot	\$ 5.00	4	\$ 20.00
Installation Time	Calvin Physical Plant	\$ 30.00	20	\$ 600.00
Floats	Walmart	\$ 12.60	4	\$ 50.40
Tubing (33ft)	WVO Designs	\$ 60.00	1	\$ 60.00
Manual Trigger Nozzle	AdBlueOnline	\$ 44.00	1	\$ 44.00
Light switches	Lowes	\$ 0.69	8	\$ 5.52
250 ft Wire	Lowes	\$ 63.24	1	\$ 63.24
Plug	Lowes	\$ 4.34	1	\$ 4.34
AC to DC converter	Lowes	\$ 31.90	1	\$ 31.90
1/4" Ready Fuel Hose (\$/ft)	Delcity	\$ 1.08	15	\$ 16.20
<b>Facilities &amp; Infrastructure TOTAL</b>				\$ 4,359.67
<b>Total Upfront Cost:</b>				<b>\$ 6,850.35</b>

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# Operating Costs = \$236/month

Student Worker Wages	Calvin College	\$	10.00	14	\$	140.00
Additional Preventive Maintenance Labor	Calvin Physical Plant	\$	60.00	1	\$	60.00
Fuel Filters	Greasecar	\$	15.00	1	\$	15.00
Fuel Injector Cleaner	Ryder Fleet Products	\$	8.00	2	\$	16.00
Cost of Industrial Space	Calvin College	\$	4.00	120	\$	480.00
Energy	Consumers Electricity	\$	5.00	1	\$	5.00
<b>Total Operating Cost:</b>					<b>\$</b>	<b>716.00</b>
<b>Total Operating Cost Less Sunk Costs</b>					<b>\$</b>	<b>236.00</b>
<b>Total First Year Costs</b>					<b>\$</b>	<b>15,442.35</b>
<b>Total First Year Costs Less Sunk Costs</b>					<b>\$</b>	<b>9,682.35</b>



# Valve Design

## Actuator Controlled Valves



Image Source: [www.praher-valves.com](http://www.praher-valves.com)

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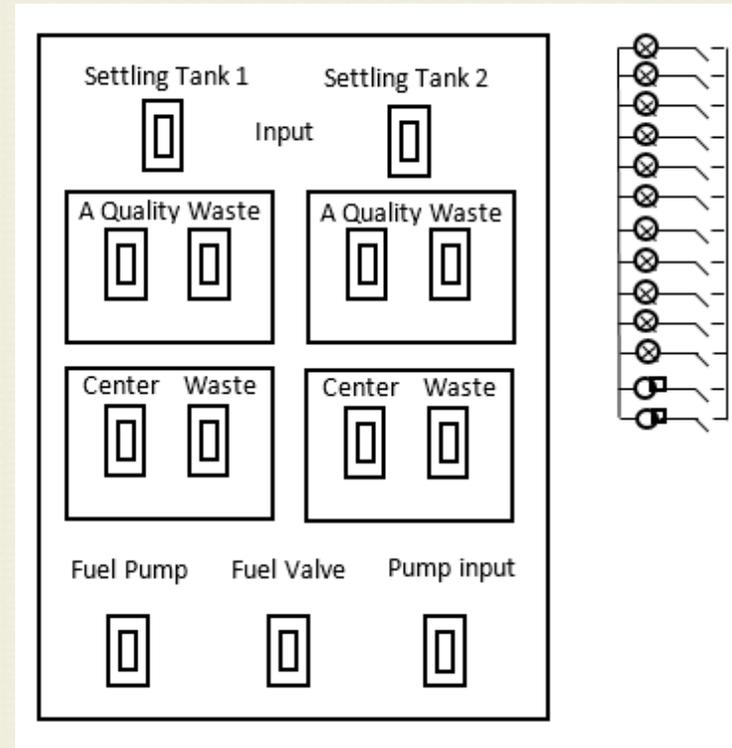
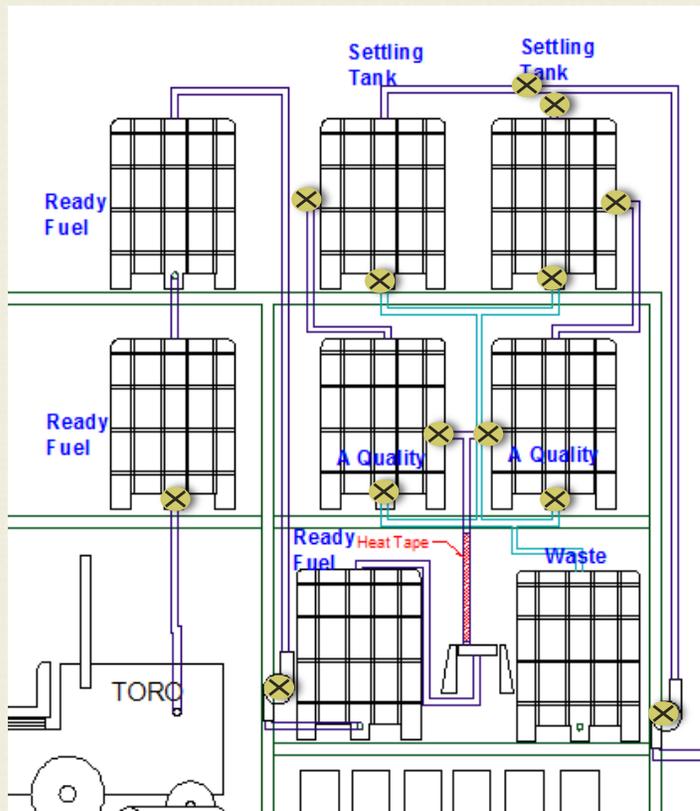


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# Valve Design

## Actuator Controlled Valves



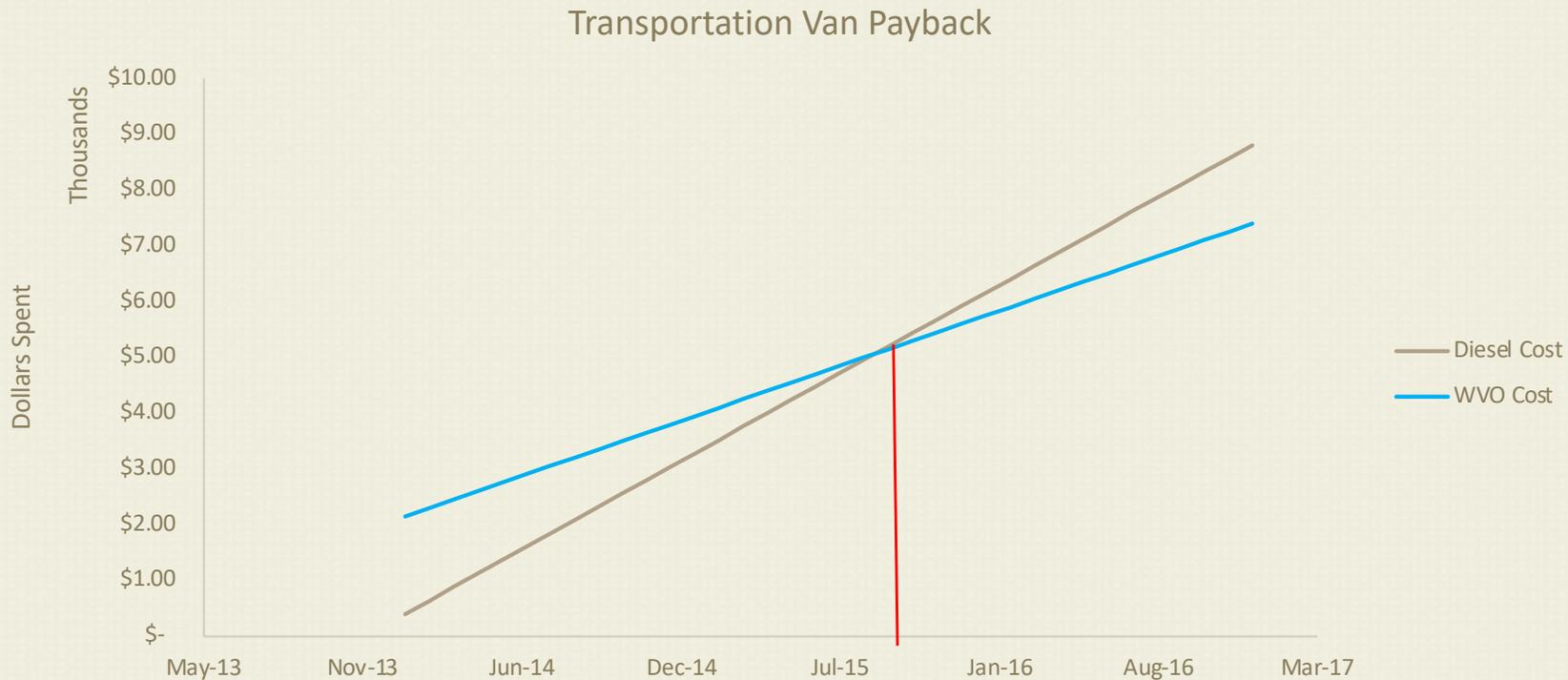
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# Transportation Van Cost Analysis

**Result: 1.5 year payback time**



12/09/2013

**CREATIVE DINING SERVICES**  
Complete Hospitality Management

