

Solid Separation, Product Drying and Oil Extraction Opportunities

National Algae Association Conference



Prepared by: Virtuoso Biofuels Services LLC

Table of Contents:

- Who We Are: (Virtuoso Biofuels Services)
- Solid Separation
 - Decanters
 - Centrifuging
 - Hydroclones
- Product Drying
 - Indirect Heat
 - Fluid Bed
 - Direct Heat
 - Microwaving
- Extraction of Oil
 - Expellers & Presses
 - Solvent Extraction
 - Supercritical Extraction
- Credits

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Who are we? (Virtuoso Biofuels Services)



Virtuoso Biofuels Services was founded by Tony Prehm and Steve Still in late spring of 2007. Each partner has a specific role within the company. Combined, Mr. Prehm and Mr. Still have over 50 years of hands on construction and operation management experience in soybean processing, ethanol from corn, biodiesel production and various other ag related industrial environments.



Our primary business is working with multiple US Biofuels companies to optimize their operations and assist them with project management, policy development and operations management and new business development. Our relationships are many and we strive to bring success to each client in any area where they feel their organization have specific needs.

We have worked with multiple algae biomass products to determine methods for extraction and have perform lab testing on methods to harvest and dry the material in preparation for oil extraction. We do not consider ourselves experts when it comes to working with algae biomass but we have had some successes as well as encountered problems with the products we have researched.

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Who are we? (Virtuoso Biofuels Services)

In addition to the two owners, VBS has 6 other employees that possess their own specific skills

- Larry Christopher: Safety and Operations Efficiency Specialist
- Curtis Abney: Quality Assurance and Chemistry Specialist
- Danny Mallen: Policy and Documentation Specialist
- Paul Voller: Site Superintendent (At one of our managed sites)
- Francine Prehm: My wife and our accounts payable clerk
- Julie Still: Steve's wife and our accounts receivable clerk

We are extremely blessed and thankful to have honest people with high levels of integrity and strong work ethic as part of our support staff.

Solid Separation



Decanters

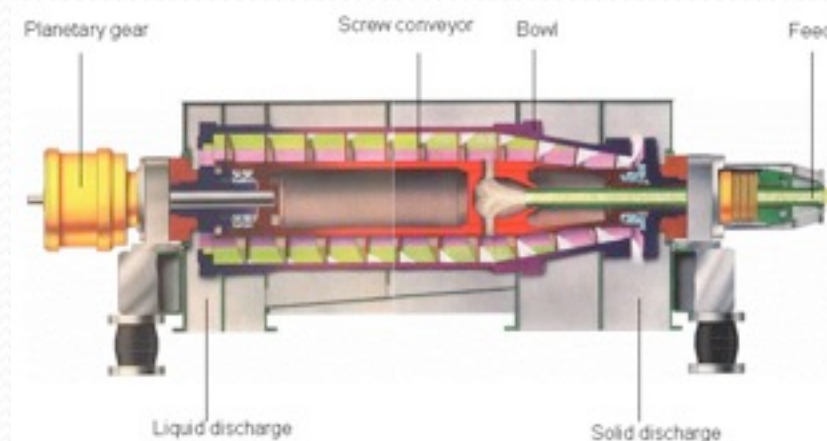
Centrifuges

Hydroclones

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Solid Separation

Decaners

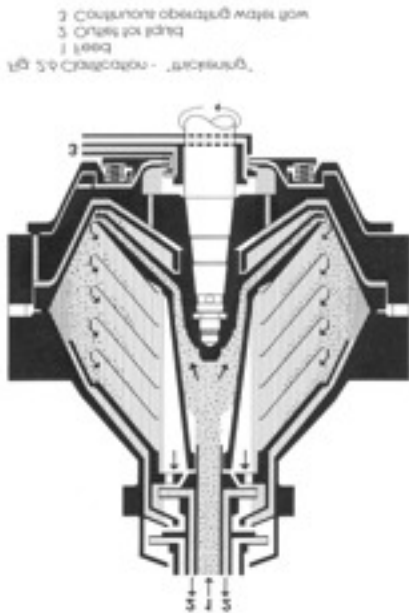


This is what is typically used in a ethanol from grain plant that takes the whole stillage once the alcohol is removed and separates the wet distillers grain from the thin stillage which is further processed to remove the moisture from the solids. This process would be a very effective way to remove the first cur of water from the photo reactor. The heavy stream would go on to further drying and the liquid stream could be recycled into the reactor or processed separately depending on each specific processors desires and needs.

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Solid Separation

Centrifuges



Centrifuges function vertically but similar to that of a decanter.

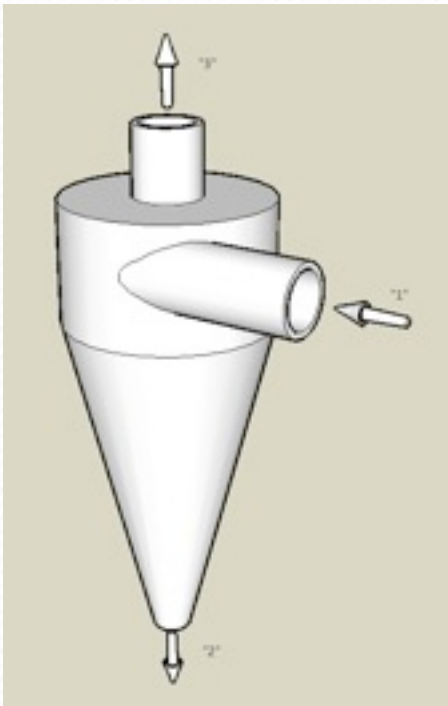
A centrifuge usually handles products that are more liquid and less solid. Typically a centrifuge similar to the “clarifier” pictured is a very efficient way to separate two liquids with different specific gravity ratings.

A centrifuge such as this could be used to separate water from in the first phase of harvest or could be used in the harvest process to remove the algae biomass from the harvested material while returning the water that is removed to the reactor or pond.

There are many other types and uses for centrifuges that could greatly improve the efficiencies of your process. There are experts present and supporting this conference here today that can help you with your product separation needs.

Solid Separation

Hydro Clones



Hydro Clones are a very effective and inexpensive method of removing solid from liquids. The wet product would enter through the horizontal line on the side. The unit needs to be appropriately sized to create the proper internal environment that will allow the heavy particles (biomass) to settle to the bottom and the water (with some residual biomass likely) to exit the top and return to the photo-reactor, pond or whatever type of system you specifically use to grow your algae. Some of the required accessories for this system are pumps and control valves.

Product Drying



Indirect
Heat

Fluid bed

Direct Heat

Microwaving

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Product Drying

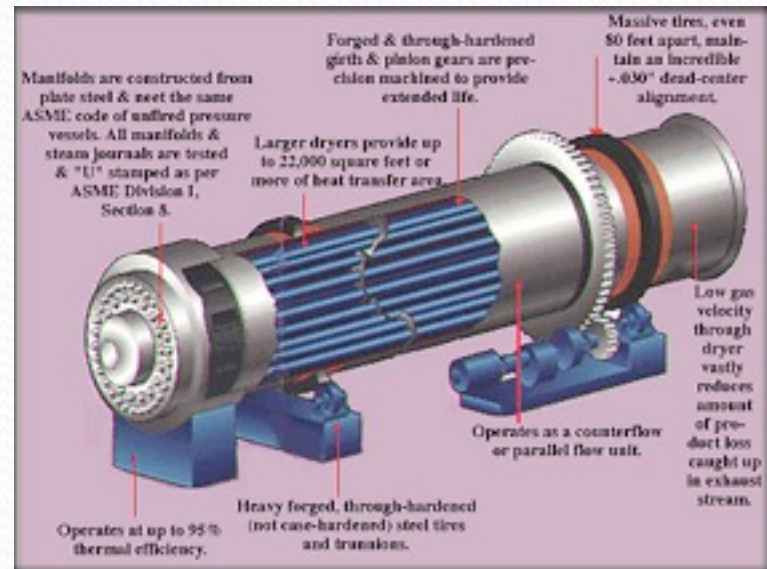
Indirect drying

Indirect steam drying is one of the most effective ways to reduce moisture content in wet product.

This process is typically very expensive due to the costs related to producing steam and the rising costs of natural gas.

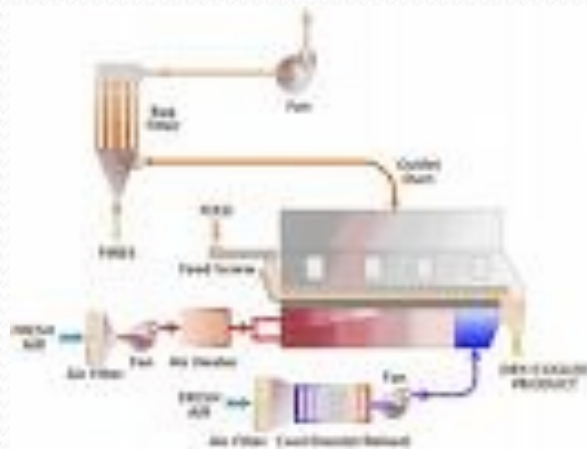
Depending on what the spent biomass is used for, it may be beneficial to take the spent biomass and feed it into a turbine process and use it as a fuel source for the production of steam and electricity. The economics of a system such as these will vary depending on steam and electricity requirements

Steam tube dryers require continual maintenance management but have low maintenance costs.



Product Drying

Fluid Bed Drying



Fluid bed drying is typically used when a starting product is relatively close to desired moisture and doesn't need a lot of percentage change to meet the desired level.

The process is very gentle and do little to no damage to the solid material which is something that may or may not be important to the you as a grower and marketer of your product.

This process has a rotating screen that allow hot air to percolate through the material carrying moisture with it as it leaves the material and vents to the atmosphere.

Fluid bed dryers have a relatively low maintenance costs

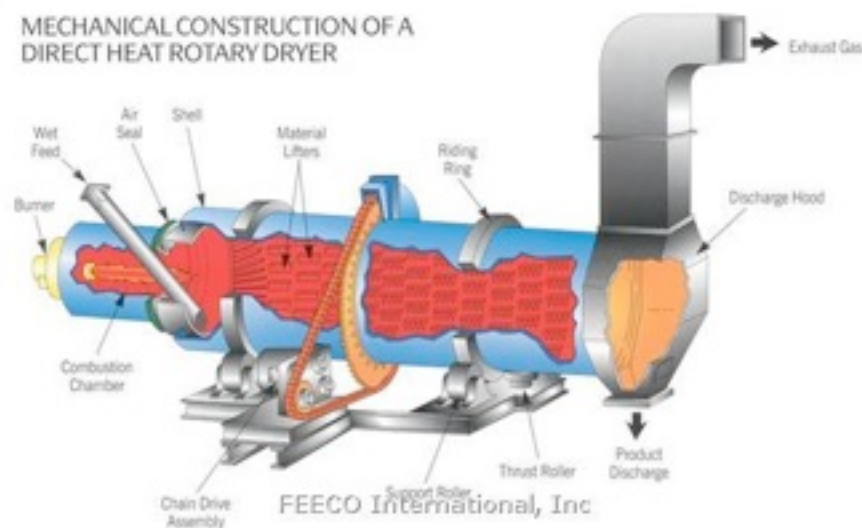
Product Drying

Direct Heat Drying

Direct heat systems use open flame usually fired by natural gas or fuel oils for the burner.

They are very effective heat sources but can create complications with other pieces of equipment due to spontaneous combustion depending on the target of the finished product

Direct heat system again are fairly expensive to operate due to the rising costs of fuels required to operate the systems. Maintenance requirements are low if the proper preventative maintenance practices are in place



Product Drying

Microwave Drying

Another technology that is currently being tested and proven using wet distillers grain from an ethanol plant starting around 50% moisture is a microwave drying system.

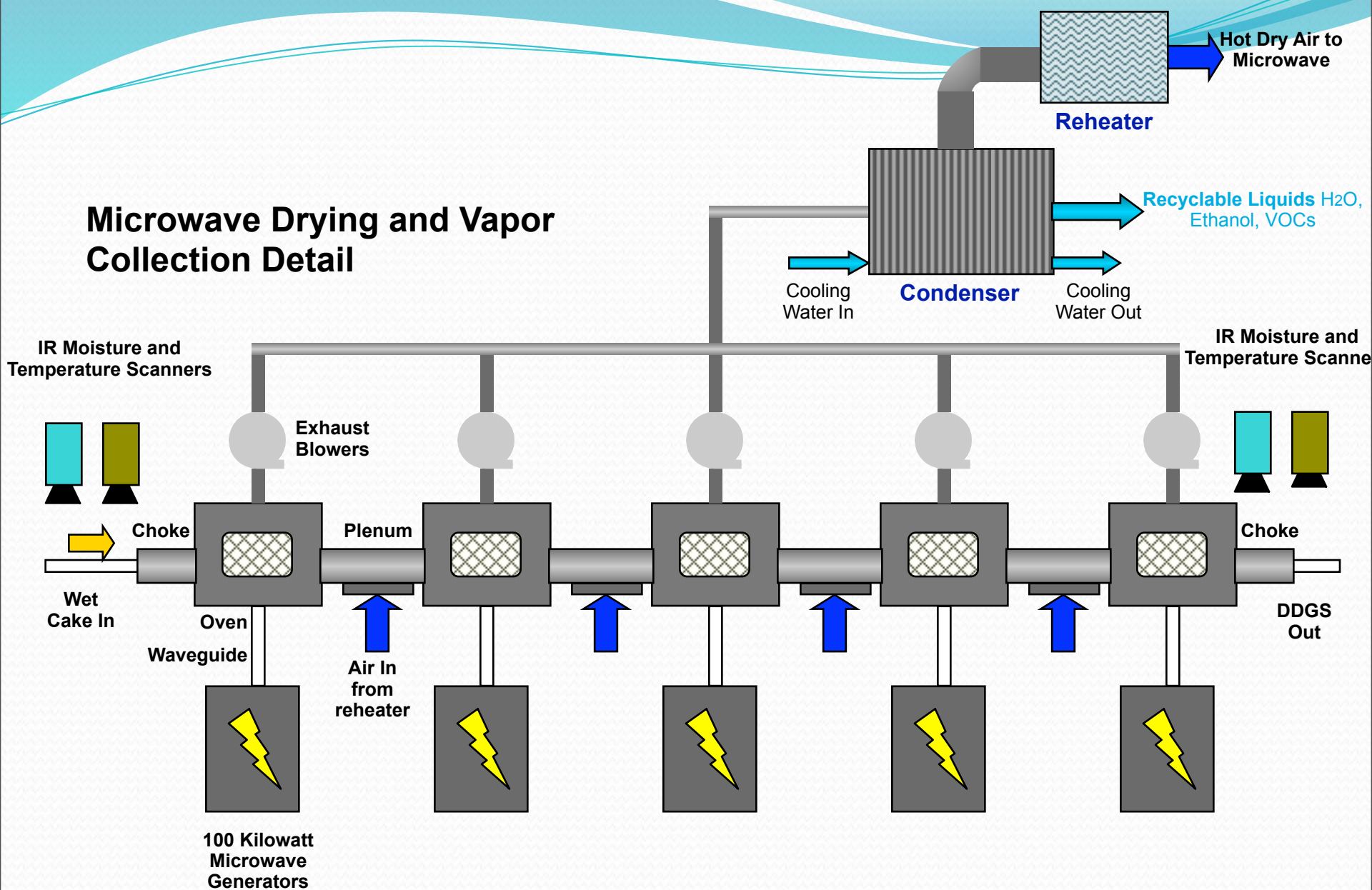
If your plant is in an area that has reasonable electrical costs or if you plan to produce your own electricity and steam using your algae biomass or other renewable product then this may be a very cost effective and efficient means to dry your product

Claimed benefits to using a microwave drying system are:

- ❖ Reduced chance for fires in your system
- ❖ Less cost per percent of moisture removed than typical steam tube dryers
- ❖ Low maintenance costs

VBS is preparing to work with this company to perform test runs to determine if the economics and effectiveness of this system on algae is as effective as they have experienced with WDGS

Microwave Drying and Vapor Collection Detail



Extraction Options



Expellers and Presses

Solvent Extraction

Supercritical

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Extraction Options

Expellers and Presses



Presses and expeller can be effective in a couple of different fashions.

Depending on the type of biomass and the amount of oil in the product, it may be required that the product run through a series of steps to rupture the oil cells and enlarge the cells making them easier to remove.



Presses are one means to rupture oil cells preparing them for extraction. They also work well to get the first phase of oil out of the product.

This equipment is often termed as “mechanical” processing and typically have high maintenance costs

Pressed and Filtered oil



Pressed and filtered oil Observations:

- Clear and Brilliant
- No Residual Settling
- No Cloud Forming
- Acceptable Color
- Acceptable Odor
- Stability unknown

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Extraction Options

Presses and Expellers



As you can see in the picture to the left, when you run the biomass through expellers and presses at the correct temperatures and pressures, they have the ability to effectively remove oil from the oil rich biomass

Also as you will notice, there is a large amount of “foots” or residual heavy product that goes with the oil that will need to be removed and recycled through the system to allow you to access the oil and improve oil yield numbers.

Presses and expeller systems are normally run on high oil content products and can typically get 80% of the available oil out of the product. That is why these are normally used in front of solvent systems.

Presses can be high cost maintenance items if not properly managed.

Extraction Options

Solvent Extraction



Solvent extractors come in many sizes and configurations

Once the oil cells are ruptured and the oil is ready for extracting the product is fed into an air tight extractor and washed with a series of solvent flow washes until the desired residual oil content is obtained.

Solvent extraction is typically done with a chemical called “Hexane” Hexane is very explosive and if not handled properly can be very dangerous.

There are hundreds of plants in the US and other countries today operating using hexane and with the proper safety protocols in place these plant operate with little or no downtime and few accidents

Hexane and other chemical should never be underestimated.

Extraction Options

Solvent Extraction



In the picture to the left, you will notice the difference between an algae biomass that has been fully extracted using a press and the white product with less residual oil is after solvent extracting the product

The starting biomass has an oil content of 49% and moisture of less than 10%

After the press the oil content in the product was around 9-11 %

The final phase was the solvent extraction which reduced the oil content to around 1.2-1.5% residual oil

Extraction Options

Supercritical Extraction



Supercritical extraction is another method that is available for extracting oil from algae.

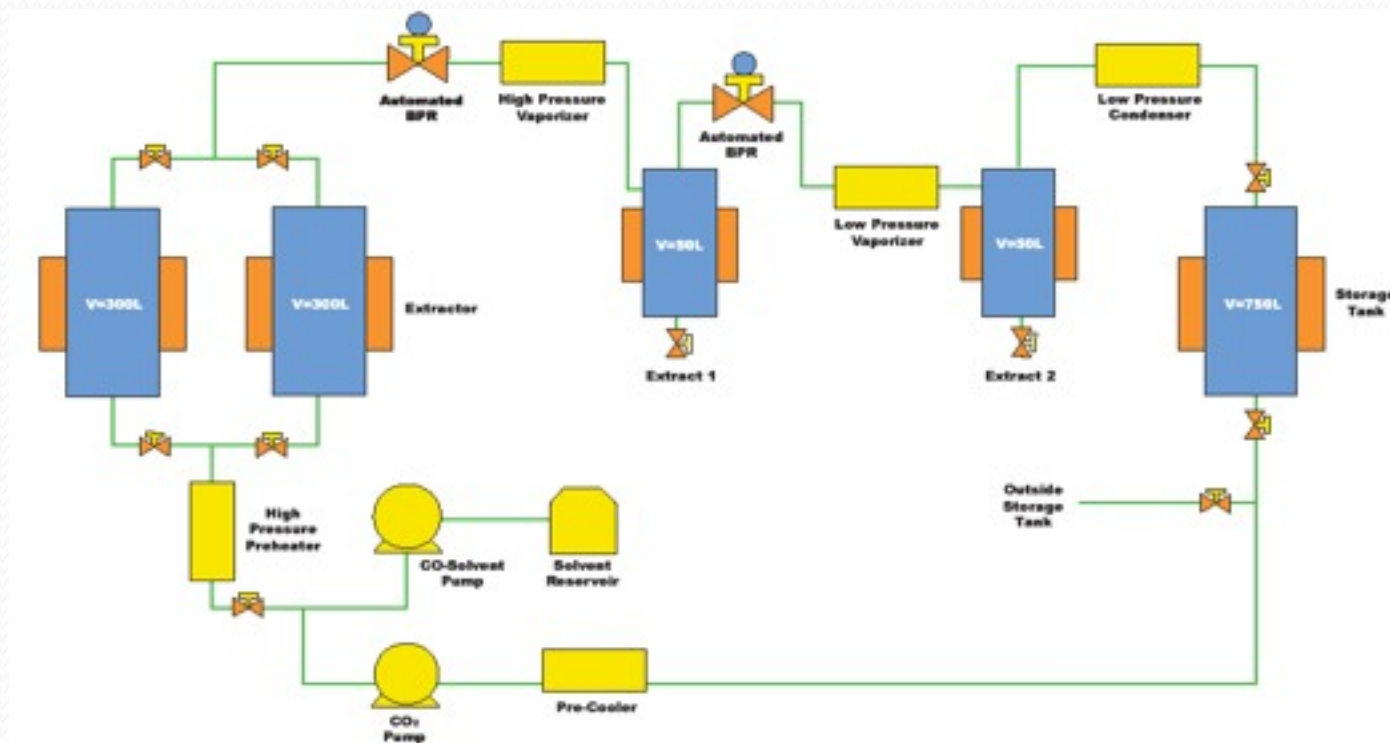
Typical advantages to SCE are the low environmental impact and the quality of the oil as well as the cake once the oil is removed

Disadvantages to the SCE are the sensitivity of the process and risks that come with high pressure systems and processes

SCE processes will also need to have the oil cells exposed although there is much less need for rupturing the cells due the high level of pressure and the use of a solvent (typically CO₂) to drive the oil from the solid or the cake

Extraction Options

Supercritical Extraction – Simply PFD



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Extraction Options

Supercritical Extraction – Advantages provided by THAR

Issue	Distillation	Solvent Extraction	Cold Press	Advantage of SCE
Quality of Extracts	Can damage thermally sensitive materials. Possible	Good recoveries, however products will retain some levels of solvent residues. Non-selective.	Non-selective. Extracts solids and other products along with desired extract. Additional	Very high purities. Excellent yields. No thermal or chemical damage to valuable
Quality of Raffinate	Raffinates are subject to thermal degradation and hydrolysis	Raffinate must be toasted or otherwise refined to remove solvent residues. Reduces quality and value of raffinate	High residual oil levels require additional extraction step if proteins and fiber are to be used for anything other than animal feed	Better protein and fiber profiles of raffinate makes for higher value products. No additional preparation or refining needed for high quality raffinate
Energy Use	High Temperatures lead to much higher energy use	Post-extraction refining such as solvent recovery from extracts, toasting of raffinate and other	Energy use is relatively low, however, as the pressure increases so does	Low operating temperatures low energy use. Little or no additional refining steps. High
Environmental Impact	High energy use and significant greenhouse gas emissions	Risk of exposure associated with handling large volume of hazardous solvents and solvent residues. Subject to strict regulatory guidelines	Relatively low environmental impact and low yields	Relatively low environmental impact. High yield solvent free extraction

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Samples

Oil



Biomass



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Credits and Recognition



To Dennis Fisher and BioCentric. Dennis and his team have supported Virtuoso Biofuels Services since our conception in 2007. We have formed a relationship based on trusting one another and working together towards a successful end.

Others that contributed to my presentation by providing material and information are:



Thar Process

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Questions

Thank you for your time

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