

32223 PDF  
Sludges

~~2091~~

THE CARVER-GREENFIELD PROCESS  
A CLEAN EFFICIENT WAY TO CONVERT SLUDGES INTO PROFIT

offered by

FOSTER WHEELER ENERGY CORPORATION

and

DEHYDRO-TECH CORPORATION

Chas Greenfield Pres.

Dehydro-Tech Corp.

6 Great Meadow Lane

E. Hanover N.J. 07936

-CONCENTRATION-  
PARTIAL WATER REMOVAL

-EVAPORATION OF WATER-  
SLUDGE IS COMPLETELY DRIED

-COMBUSTION-  
ENERGY PACKAGE

-PRODUCTS-  
FOR PROCESS OR SALE

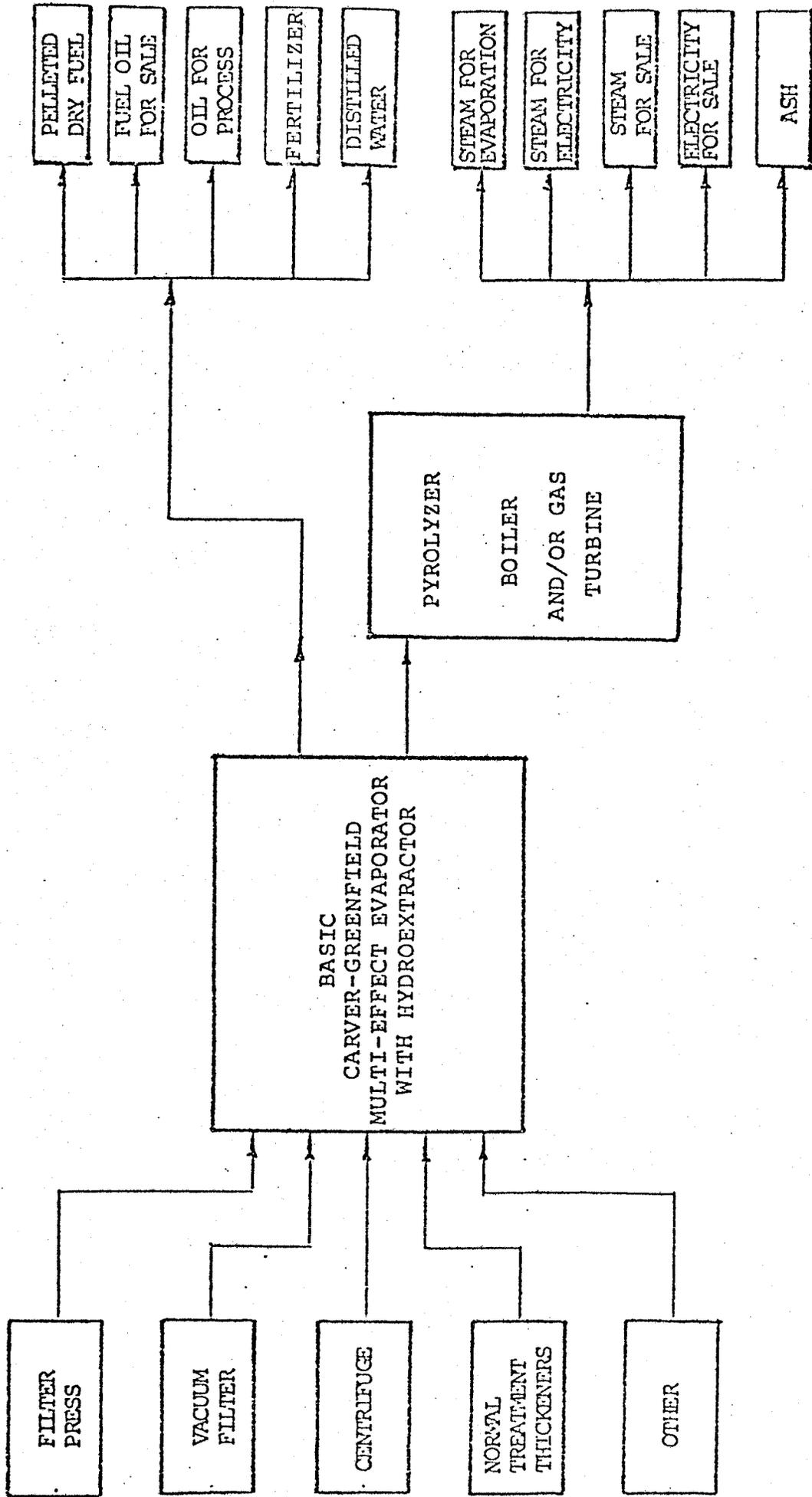


DIAGRAM ILLUSTRATING THE FLEXIBILITY OF THE CARVER-GREENFIELD PROCESS  
USERS CAN SELECT DIFFERENT PROCESS OPTIONS TO SUIT THEIR NEEDS

## INTRODUCTION

The Carver-Greenfield Dehydration Process is a modern, clean, extremely flexible method for dehydrating water-bearing sludge to produce either a sterile fertilizer, or solids for conversion to energy. Over 65 plants with this process are in operation today.

Oil and grease, as well as other organics such as pesticides and PCG's that may be found in the sludge, are extracted and may be used as a clean fuel oil for sale or for other energy purposes.

The process, which is offered jointly by Foster Wheeler Energy Corporation and Dehydro-Tech Corporation, has two unique features:

- 1) The addition of a typical petroleum hydrocarbon oil to fluidize the sludge flow. This arrangement permits efficient evaporation of the water, leaving a suspension of dry solids in the oil, without the usual problems of scaling the metal surfaces. Simple established methods are used to separate and recycle the oil, leaving a solid product that is dry, sterile and oil-free.

- 2) The evaporation of the water is carried out in a multi-effect evaporator. This evaporator requires only 20 to 30% of the heat energy input of a conventional sludge drying system. The principle of multi-effect evaporation has been used for many years in the sugar, paper and desalination fields.

#### BRIEF PROCESS DESCRIPTION

The Carver-Greenfield Process can start with either digested or undigested sludge containing 3 to 5% solids. Where existing settling ponds or lagoons are in use, sludged recovered at 12 to 15% solids can also be fed to the Carver-Greenfield Process.

However, for a new plant, polymer assisted centrifugation or filtration will be employed to concentrate the 3 to 5% sludge to 15 to 20% solids. This material is ground, mixed with a hydrocarbon oil and fed to the multi-effect evaporation system where the water is vaporized in a series of evaporators.

Steam, at a pressure as low as 50 psig, is condensed in the final, or drying stage and the steam generated on the process side of that stage passes backward to evaporate water in the incoming feed to the preceding stage.

The slurry of dry solids in oil leaving the last or drying stage, is separated into dry solids and oil.

Interestingly enough, grease or oil, as well as organic pesticides contained in the feed, will dissolve in the recycle oil phase and are separated from the oil by distillation. This residual liquid is available as a fuel oil for firing in either a new or existing boiler where the pesticides are completely destroyed.

It should be noted that typical sewage sludges contain 10 to 20% oil, most of which is recovered by the Carver-Greenfield Process. Enough oil is normally recovered to supply the entire steam requirements of the process.

Because the water in the feed has been separated by evaporation as compared to mechanical separation techniques, it is of distillate quality and, with simple treatment, may be used as boiler feed water or cooling tower makeup.

The dried solids which have been sterilized at the evaporation temperatures used, are now pelletized for use as a storable fertilizer component. As an alternative, the pelletized solids may be sold or used as a boiler fuel. Perhaps the most important option is to pyrolyze the pelletized dry solids to produce a fuel gas to be fired in a combined steam-gas turbine cycle to produce electricity.

Obviously, many arrangements are possible depending upon the economic factors involved. These include the cost of capital, fuel, and electrical power.

#### ADVANTAGES

The Carver-Greenfield Porcess offers the following advantages:

- 1) The plant is completely free from pollution and it has an attractive appearance. It is quiet in operation and odor free. Water evaporated in the Carver-Greenfield Process is of high quality and does not require any further treatment costs. Gaseous vents from the system are sent to the boiler or pyrolyzer for destruction making the plant odor free. Solids are produced as a fertilizer with pathogens and viruses completely destroyed, or if used as an energy source, pyrolysis is employed, and the solids are disposed of as ash. (Heavy metals may be extracted and recovered from this ash, particularly if pyrolyzed rather than incinerated).

- 2) The process is highly flexible in application and can be optimized to process sludge at the lowest cost known per dry ton for any particular set of economic conditions and environmental requirements. An important reason for this is the low energy requirement of the efficient multi-effect evaporators. In almost every case with municipal sewage sludge, the cost to a municipality will be below present barging or reported composting costs.
- 3) The Carver-Greenfield Process lends itself to automation. The optimum degree of automation may be determined by an economic evaluation.
- 4) The Carver-Greenfield Process employs well proven techniques and equipment.
- 5) The plot area required for the plant is minimal and the flexibility of the process allows it to be adapted in most instances to the available land.

#### EXPERIENCE

The Carver-Greenfield Process has been used for many years in the animal fat rendering field where bones, waste fat

and vicera by-products are dehydrated to produce marketable products such as fat and protein. Over 50 such plants are in operation.

Two Carver-Greenfield plants are now successfully operating in Japan dehydrating night soil and sewage sludge.

In the industrial area, there are twelve plants in operation dehydrating waste sludges from pharmaceutical, brewery, dogfood, candy and dairy product manufacturing operations.

Recently, a large brewery started up a Carver-Greenfield Process Plant handling activated sewage sludge from the brewery's treatment plant. It is their intention to market the dried pelletized product as an animal feed. However, during the interim period, before this product is approved by the Federal Food and Drug Administration for such use, this company will be using the product as a soil conditioner-fertilizer and as a fuel. The total value of the animal feed has been calculated to provide a profitable operation for this company.

In another case, a Dehydro-Tech installation including evaporation and pyrolysis units will be starting up in early Spring of this year at a large pharmaceutical plant. The fuel gas generated by pyrolysis in this 50 dry tons/day unit will be burned in a pollution free manner in a boiler supplying steam to the dehydration process with surplus steam to the production plant.

### PILOT PLANT AVAILABLE

A mobile pilot plant is available for tests and has recently demonstrated successful application of the process on sewage sludge for the City of Los Angeles. A further test, to which all interested parties are invited, is scheduled for Spring 1977 at the LA/OMA Project also in California.

### PROSPECTS FOR CARVER-GREENFIELD PROCESS PLANTS

Foster Wheeler Energy Corporation and Dehydro-Tech Corporation jointly, are very active in marketing the Carver-Greenfield Process throughout the United States and many parts of the world.

We have a most active interest from the City of Los Angeles and the City of New York, as well as developing interest from Chicago, Houston, Milwaukee, Portland, Salt Lake City and other communities.

Our two organizations are prepared to supply detailed process information, estimates of installed costs, and process economics.

It has been calculated that a 60 dry ton/day Carver-Greenfield Plant---adequate for a community of 600,000 people, or an industrial community with half as many people---can be profitable to the community when processing a 3% digested sewage sludge to complete dryness and converting the dry solids to process steam, surplus electricity and ash.

The above calculations were based on the cost of electricity at 5.9¢/kilowatt/hr. At 3¢/KWH, the operating costs for this size plant would be about \$14.4/dry ton. The assumption was made that the community's amortization cost was equivalent to 12-1/2% of the capital investment.

#### COMBINED REFUSE AND SEWAGE SLUDGE PROCESSING

The Carver-Greenfield Process can process sewage sludge and metal free refuse together, and achieve the same multi-effect evaporator efficiency described previously. It is important to note that metal-free refuse contains 35% water which can also be evaporated in the process, resulting in considerable overall energy savings. It has been estimated that the daily total sludge and refuse of New York City, if combined and dehydrated by the Carver-Greenfield Process, could result in a plant of about 1,000,000 kilowatts capacity.

#### OTHER IMPORTANT APPLICATIONS

Besides dehydrating municipal sewage sludge, the Carver-Greenfield Process has other important applications. Notable among these are:

- Black liquor concentration and drying in the pulp and paper industry. There has been considerable

interest focused on the Carver-Greenfield Process in recent months by almost every major paper company in recognition of its ability to treat black liquor economically. Foster Wheeler and Dehydro-Tech will soon begin their first cooperative effort working on a black liquor drying project for a major paper company in the Pacific Northwest.

- Drying of coal fines and lignite to reduce freight costs or to prepare dry feed to coal conversion processes.
- Drying of waste sludges from petroleum refining, chemical processing and pollution control processes. An example of this is the large amount of sludge by-product from wet scrubbing stack gas cleanup systems. This is sludge from air pollution control program. In the case of water pollution abatement, biological oxidation results in the production of secondary sludge which is the result of excess bacteria growth.

## SUMMARY

The Carver-Greenfield Process is the best process available for drying difficult-to-handle, water-bearing sludges, whether they are from industrial or municipal sewage wastes. The process is environmentally clean, thermally efficient and economically attractive for any possible type of sludge drying application.

We find that the Carver-Greenfield Process is the most suitable method to utilize for the production of a fertilizer component. It is made with a lower production cost, and has a lower oil and fat content than fertilizer made from sludge by other methods. The Carver-Greenfield product is completely dried, pelletized, storable, free of pathogens, viruses, and with minimal PCB's and insecticides. Further, the dried material is free flowing and can be distributed by standard fertilizer equipment, or used as a component in a blended fertilizer.

In those cases where it is not desired to make fertilizer or where the heavy metal content will not permit soil application, the Carver-Greenfield Process can then convert the dry solids to energy. The U.S. Environmental Protection Agency has recently reported that they are working on effective ways to remove heavy metals from sewage sludge and the Carver-Greenfield Process can effectively utilize this development. Should such a technique be developed, the process can then produce a fertilizer component that is comparable in purity to chemical fertilizers made for general agricultural use.

The Carver-Greenfield Process, therefore, is important to municipalities and industries with waste sludge problems. It is a low-cost and clean way to convert otherwise useless, disease-bearing wastes and sludge into something with definite economic value---either as sterile, dry fertilizer or as a convenient form of energy, i.e. fuel gas or electricity.

CENTRIFUGING, MULTI-EFFECT DRYING AND ENERGY RECOVERY

ECONOMICS

	<u>PLANT CAPACITY</u>		
	<u>25 TONS/DAY</u>	<u>60 TONS/DAY</u>	<u>125 TONS/DAY</u>
<u>Capital Investment</u> (includes energy package)	\$5,800,000	\$8,300,000	\$12,400,000
<u>Operating Costs</u>			
Municipality Portion of Amortization Costs Investment x 10% x 12.5%	\$ 73,000	\$ 104,00	\$ 155,000
Repairs and Maintenance @ 2.5% of Investment	145,000	208,000	310,000
Insurance @ 1% of Inv.	58,000	83,000	124,000
Labor @ \$22/hr. - 10 men	220,000	220,000	220,000
Make up Light Process Oil	9,000	22,000	46,000
Concentration Centrifuge Polymer Cost \$6.40/dry ton	<u>58,000</u>	<u>140,000</u>	<u>292,000</u>
<u>TOTAL OPERATING COSTS/YEAR</u>	<u>\$ 563,000</u>	<u>\$ 777,000</u>	<u>\$1,147,000</u>
<u>Credits</u>			
Surplus Electricity @ 3¢/KW	\$ 76,000	\$ 394,000	\$ 932,000
Surplus Steam @ \$1.50/1000 lbs.	<u>36,000</u>	<u>68,000</u>	<u>219,000</u>
<u>TOTAL CREDITS</u>	<u>\$ 112,000</u>	<u>\$ 462,000</u>	<u>\$1,151,000</u>
Net Operating Cost or Credit	\$ 451,000	\$ 315,000	\$ 4,000 Cr.
Net Cost/Dry Ton <sup>(1)</sup>	\$ 49.40	\$ 14.40	\$ .10 Cr.
Net Operating Cost if Electricity Valued at 5.9¢/KW <sup>(1)</sup>	\$ 41.30	\$ 3.00 Cr.	\$ 19.84 Cr.

(1) See attached bar graph

CENTRIFUGING AND MULTI-EFFECT DRYING

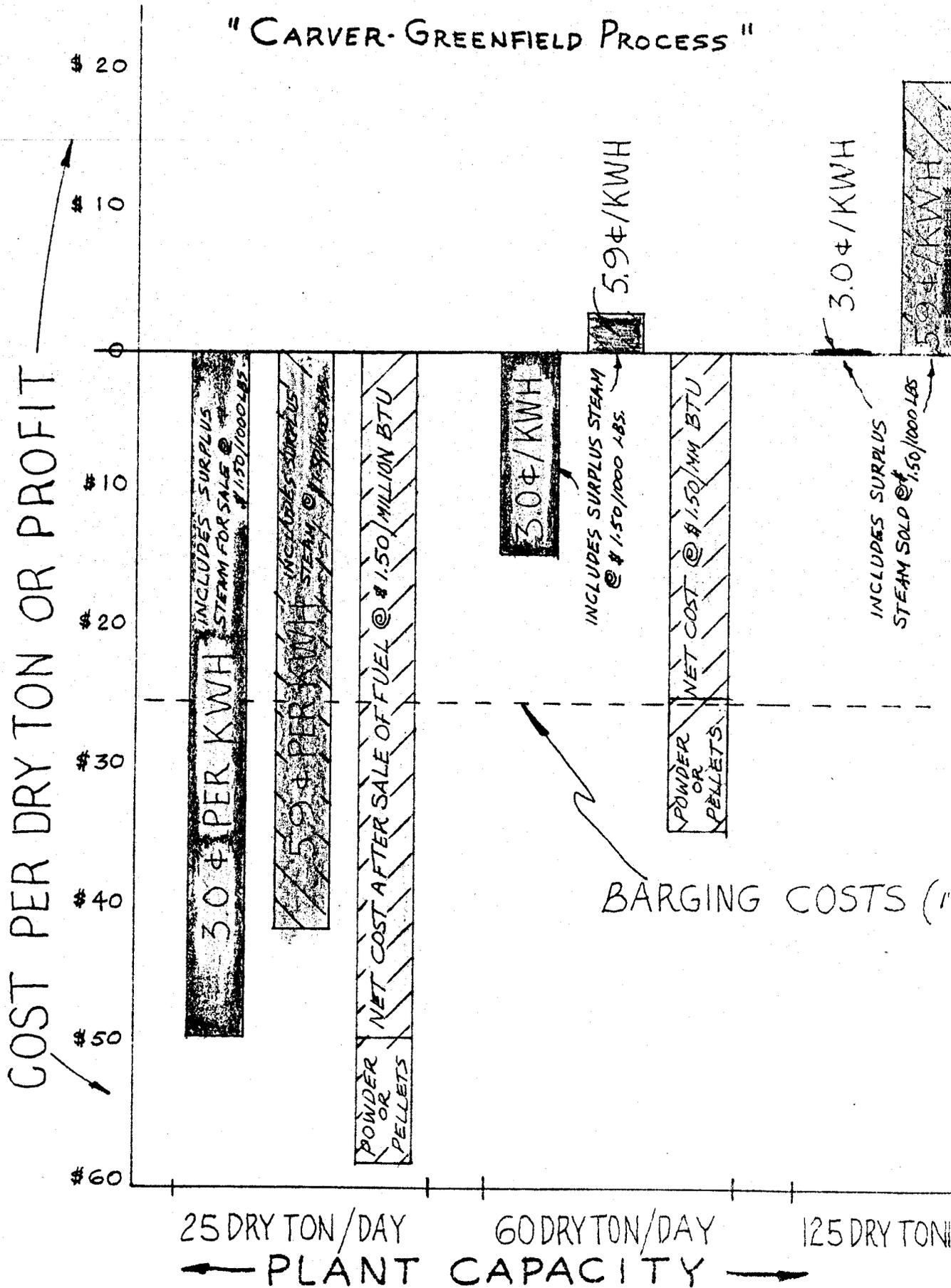
ECONOMICS

	<u>PLANT CAPACITY</u>		
	<u>25 TONS/DAY</u>	<u>60 TONS/DAY</u>	<u>125 TONS/DAY</u>
<u>Capital Costs</u>			
Carver-Greenfield Process	\$2,700,000	\$4,000,000	\$6,000,000
Centrifuges	<u>800,000</u>	<u>1,100,000</u>	<u>1,700,000</u>
	\$3,500,000	\$5,100,000	\$7,000,000
<u>Electricity Requirements</u>			
Carver-Greenfield Process KW	350	450	835
Centrifuges KW	<u>90</u>	<u>180</u>	<u>375</u>
TOTAL KW	450	630	1,210
<u>Operating Costs</u>			
Municipality Inv. Amortization Inv. x 10% x 12.5%	\$ 44,000	\$ 64,000	\$ 94,000
R&M @ 2½% x Inv.	88,000	128,000	192,000
Insurance @ 1%	35,000	51,000	77,000
Labor	180,000	180,000	180,000
Make up Oil	9,000	22,000	46,000
Centrifuge Polymer	58,000	140,000	292,000
Electricity @ 3¢/KW	<u>118,000</u>	<u>166,000</u>	<u>318,000</u>
TOTAL OPERATING COSTS/YEAR	\$ 532,000	\$ 751,000	\$1,201,000
Cost/Dry Ton	\$58.30	\$34.30	\$24.30
Credit @ \$1.00/million BTU as a Fuel	<u>9.40</u>	<u>9.40</u>	<u>9.40</u>
Net Operating Cost Per Dry Ton (1)	\$48.90	\$24.90	\$16.90

(1) See attached bar graph

# DEHYDRO-TECH CORPORATION

## "CARVER-GREENFIELD PROCESS"



PLEASE NOTE: THE COSTS (IF ANY) FOR ASH REMOVAL HAVE NOT BEEN INCLUDED.