Advancing Energy Optimization Strategies in Dewatering & Drying of Distillers Grains

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Motivation and Objectives

The dewatering and drying of distillers' grain is a critical yet energy-intensive step in ethanol production, contributing significantly to high operational costs and carbon emissions due to excessive fuel use and inefficient heat utilization.

This is aimed at converting the byproduct of corn ethanol production known as Distillers Grain (DG) into high-value products Dried Distillers Grain with Solubles (DDGS) which is used for animal feed. A typical wet cake from the reboiler during distillation has ~60-80% moisture content called the whole stillage.

Process Description

- ❑After the ethanol extraction step, what is left behind is a **whole stillage (WS)** - a slurry made up of water, yeast cell, fiber, protein oil and dissolved solids. This contain ~60-80 % water.
- ❑The WS is sent to **centrifugation** which is a mechanical dewatering to separate the solid (**wet cake~30-35% solids**) from the liquid (**thin stillage~5-10 % solids**)
- ❑Thin stillage is sent to a multi-effect evaporator to remove water and produce a thicker **syrup** called "**condensed distillers solubles**' (**CDS** or Syrup ~25-30% solids)
- ❑The **wet cake** is sent to the **thermal dryer** (Rotary drum) to further reduce the moisture to ~10-12% **DDGS** for shelf stability and ease of transport. This is an energy intensive process where the wet material tumbles and dries through contact with hot air. Exhaust from the dryer are sent to the RTO for the treatment of VOCs.

Note: Some other forms of DGs are 1. Wet Distillers Grain with Solubles (**WDGS ~65%** moisture) and Modified Distiller Grain with Solubles (**MDGS~54%** moisture)

This process is fully shown in the process flow diagram in **Figure 1** containing the mass balance of the entire process.

Process Flow Diagram

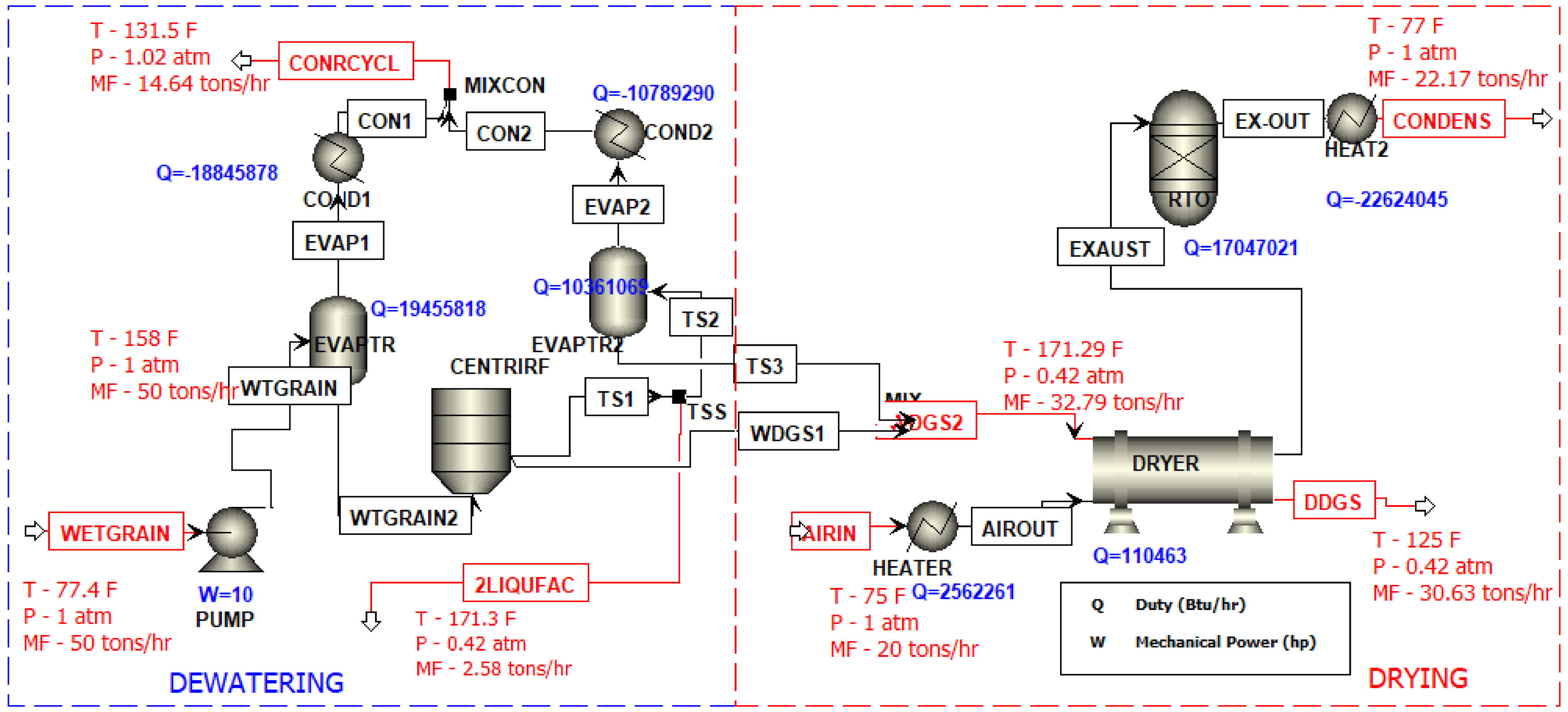


Figure 1. *Process Flow Diagram of the Dewatering & Drying Section*

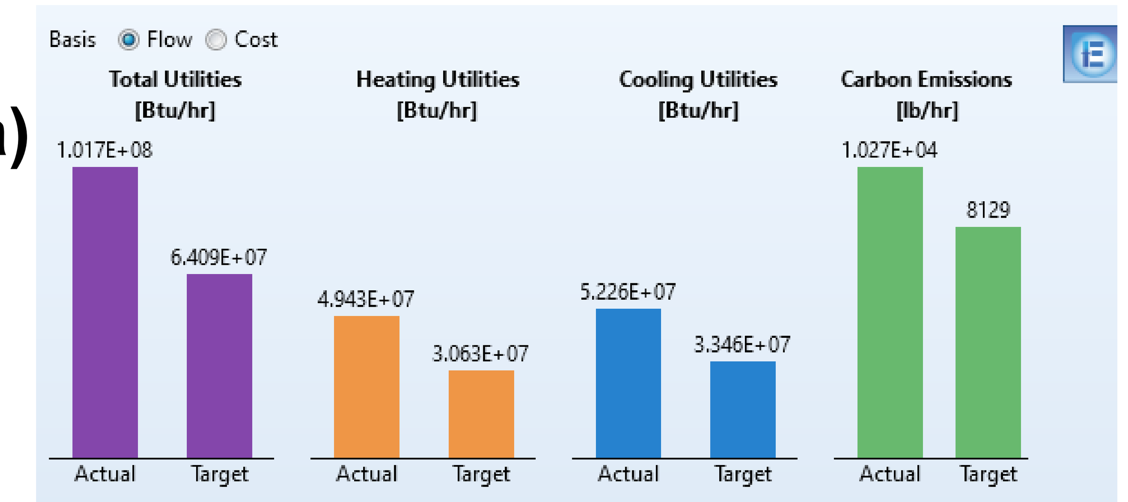
Results and Discussion

1. Potential Energy Savings

In Aspen Plus, **Potential Energy Savings** represents the amount of energy that can be saved by optimizing the process, often identified through **Pinch Analysis** or **Heat Integration Studies**.

Energy	
Available Energy Savings	
3.76E7	36.97
Btu/hr	% of Actual

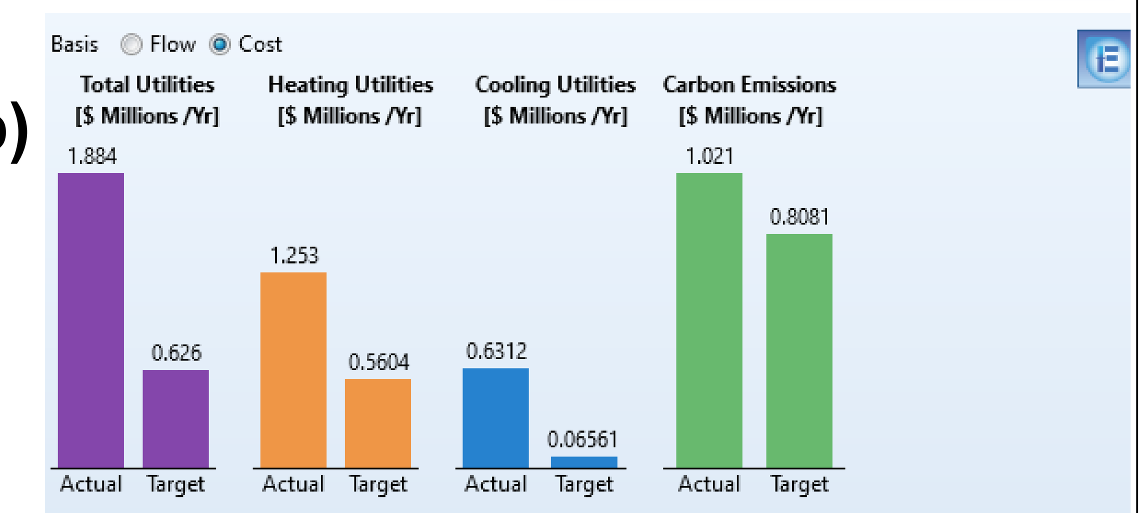
(a)



Summary Table

	Actual	Target	Available Savings	% of Actual
Total Utilities [Btu/hr]	1.017E+08	6.409E+07	3.76E7	36.97
Heating Utilities [Btu/hr]	4.943E+07	3.063E+07	1.88E7	38.03
Cooling Utilities [Btu/hr]	5.226E+07	3.346E+07	1.88E7	35.97
Carbon Emissions [lb/hr]	1.027E+04	8129	2140.00	20.84

(b)



Summary Table

	Actual	Target	Available Savings	% of Actual
Total Utilities [$ Millions /Yr]	1.884	0.626	1.26	66.78
Heating Utilities [$ Millions /Yr]	1.253	0.5604	0.69	55.28
Cooling Utilities [$ Millions /Yr]	0.6312	0.06561	0.57	89.61
Carbon Emissions [$ Millions /Yr]	1.021	0.8081	0.21	20.83

Figure 2. *Available energy savings for the dewatering and drying process (a) flow basis and (b) utilities cost analysis*

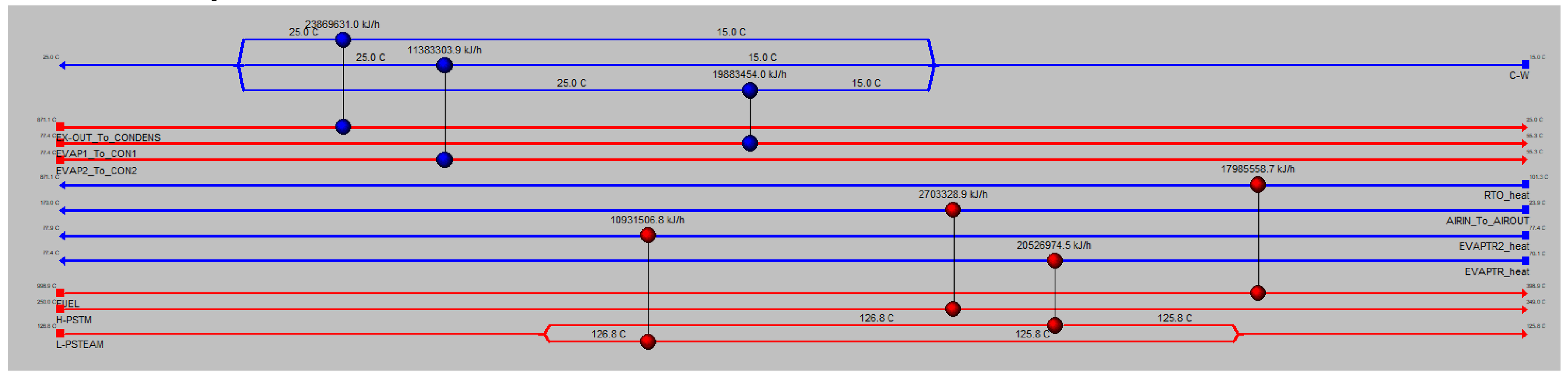


Figure 3. *Heat Exchanger Network System for the entire process.*

2. Greenhouse Gas (GHG) Emissions

The dewatering and drying of DGs can lead to significant GHG emissions, primarily due to the energy-intensive nature of the process involved.

Greenhouse Gas Emissions		
Scope 1 CO2 equivalent	0	lb/hr
Scope 2 CO2 equivalent	12920	lb/hr
Total Carbon Tax	146.51	$/hr

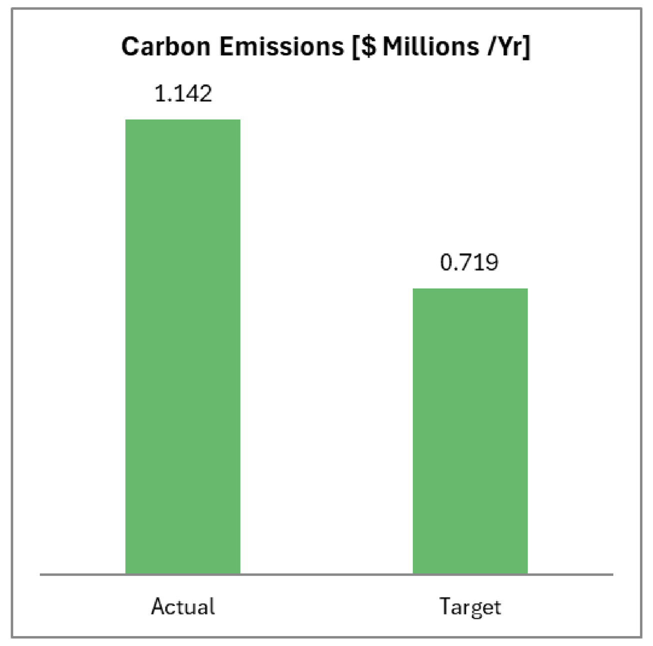


Figure 4. *Annual Carbon Emission for the entire process*

Conclusion

- ✓ The available energy savings of 3.76E7 Btu/hr, which corresponds to 36.97% of the actual energy consumption.
- ✓ Improving Heat recovery, optimizing utilities, and refining process conditions, the plant can reduce its energy consumption by nearly 37%, leading to lower operational costs and a reduced environmental footprint.
- ✓ There are no scope 1 CO_2 equivalent emission because Aspen plus consider the utilities need for the process outside the boundary scope of the plant.
- ✓ Ultimately, advancing energy optimization in this area will lead to a more sustainable and economically viable ethanol industry, supporting both environmental goals and energy efficiency.

References

1. Bhatt, A.H. et al. (2022), J. Clean. Prod., 362(13), 2409
2. Blumberga et al. (2020), *Energies*, *13*(9), 2170

Acknowledgements

NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

This work was supported by the Nebraska Public Power District through the Nebraska Center for Energy Sciences Research at the University of Nebraska-Lincoln.