NGL PRO
FLARE REDUCTION, NGL RECOVERY AND GAS CONDITIONING

Aspen Engineering Services, LLC

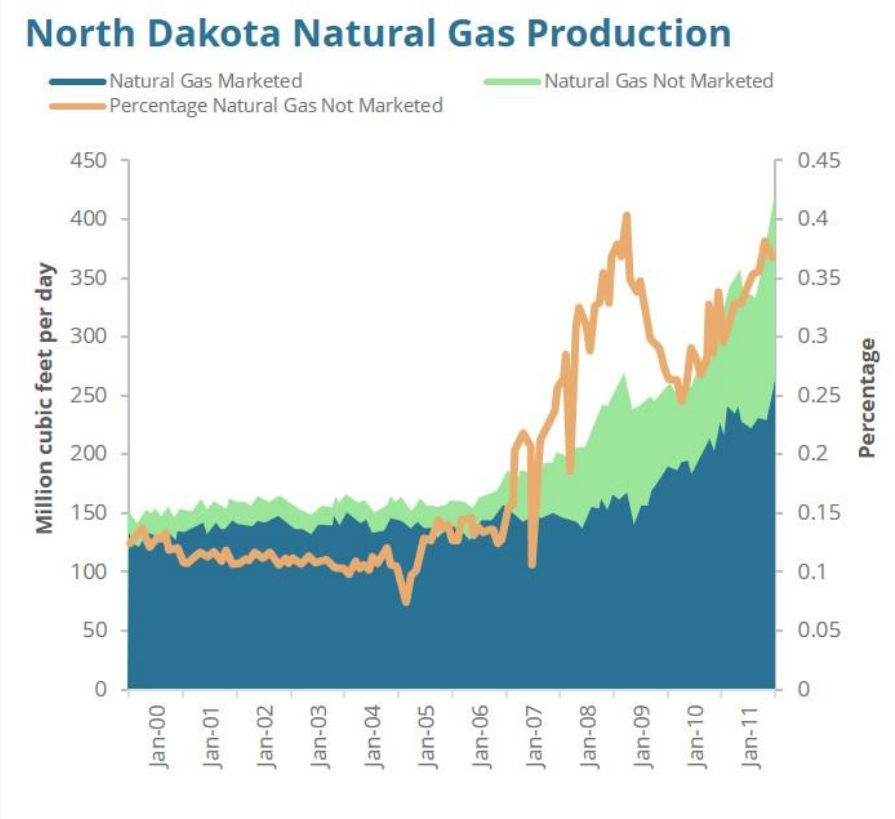
Solutions for the Oil and Gas Industry

PRESENT CHALLENGES TO THE OIL AND GAS INDUSTRY DAILY PRODUCTION

Flaring Gas To Atmosphere

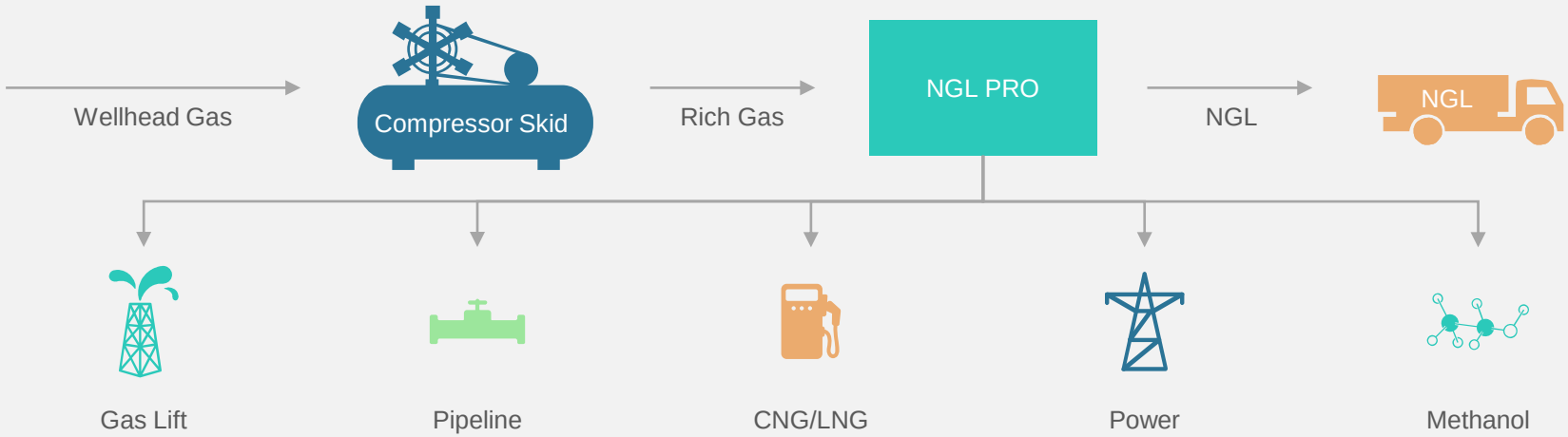
Pipeline infrastructure is often unavailable

Flare recovery equipment has traditionally been expensive, maintenance intensive, and requires additives to prevent ice and hydrate formation.



Deadline	Flaring Limit (Percentage Gas Produced)
October 1, 2014	26
January 1, 2015	23
First Quarter 2016	15
Fourth Quarter 2020	10

NGL PRO PROCESS DESCRIPTION



NGL PRO SKID

The NGL Pro system will consist of two portable skids that are transported over the highway on flatbed trucks. One skid contains a standard reciprocal compressor package. The other skid contains the proprietary NGL Pro process. The NGL Pro skid is produced in a weld shop from commonly available oil and gas equipment. The prefabricated equipment will be set near the wellhead and field connected.

The NGL Pro process is comprised of the following steps:

1. Rich natural gas is compressed in a three stage reciprocal compressor. Inter-stage liquid condensation is avoided by controlling the outlet temperature of the inter-stage air coolers
2. The compressed gas is cooled after the third stage of compression by heat integration and air cooling
3. The cooled mixture of lean natural gas, NGL and water are separated in a three-phase separator
4. The NGL from the three-phase separator is heated to prevent ice and hydrate formation before depressurization
5. The two-phase mixture from step four is depressurized, and then stabilized by hot gas from the compressor. The NGL liquid from the bottom of the stabilizer is conditioned for storage and transfer in standard propane bullet tanks. The NGL Pro process without the JT cooling is well-suited for colder climates such as North Dakota. For warmer climates, JT cooling compensates for the lack of ambient cooling.

NGL PRO OVERVIEW

The NGL Pro process recovers NGL from rich natural gas without refrigeration or additives. Rich natural gas is first compressed, and then cooled in four heat exchangers. The liquid/gas mixture is then separated into lean natural gas, NGL and water. Hydrate formation in the lean gas and NGL is precluded by heat integration with the hot compressed gas before depressurization. The NGL is stabilized to reject ethane and conditioned for storage and transport in common propane tanks. The lean natural gas is suitably conditioned for internal combustion, compressed natural gas, liquefied natural gas or liquid fuel processing.

BACKGROUND

The combination of **horizontal drilling and fracking has caused an oil boom across the United States**. Most notably, the Bakken oil field of North Dakota is growing exponentially. Flaring from crude oil operations in the Bakken oil field of North Dakota has become an enormous economic and environmental issue. The horizontal drilling and fracking process co-produces natural gas. The co-produced gas is normally compressed and sent down a pipeline. However, in the Bakken, for example, the pipeline infrastructure has failed to keep pace with drilling. Oil wells in the Bakken flare co-produced gas because of a lack of pipeline infrastructure . The wells that are flaring gas in the Bakken have created a problem so severe that it can be seen from space (refer to Figure 1). legislation to curtail flaring in the Bakken will also curtail oil drilling unless flaring alternatives are developed.

FLARE ELIMINATION STRATEGY

The NGL Pro process strategy utilizes a standard compressor skid, NGL Pro skid and residue gas consumption process. The removal of NGL using the NGL Pro skid is essential for two reasons. First, lean gas (similar to typical methane natural gas) is necessary for power generation, CNG, LNG or methanol production. Specifically, natural gas powered engines, used to drive generators run poorly on rich natural gas. Second, the value of the NGL is much higher than natural gas, and it simply makes good business sense to recover the liquids. The recovered liquids are stored in a standard propane bullet tank. Portable bullet tanks are readily available and existing NGL logistics companies are eager to collect and deliver the NGL. The gas lift system is a process to stimulate oil from the well by sending lean compressed gas down to the bottom of the well bore.

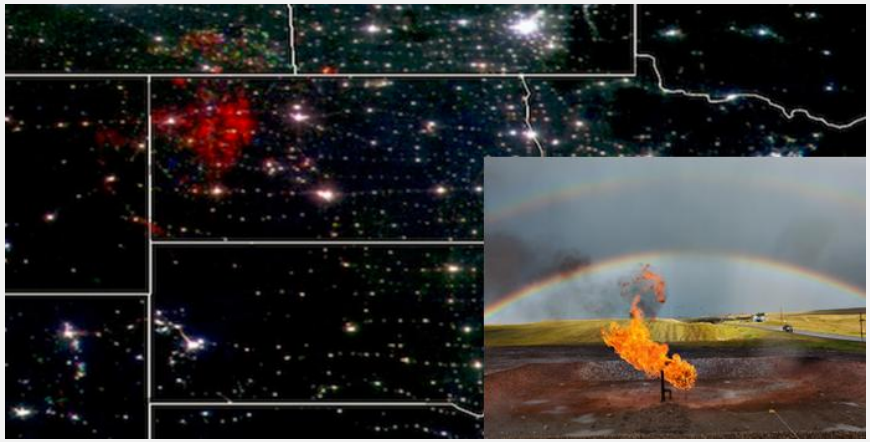
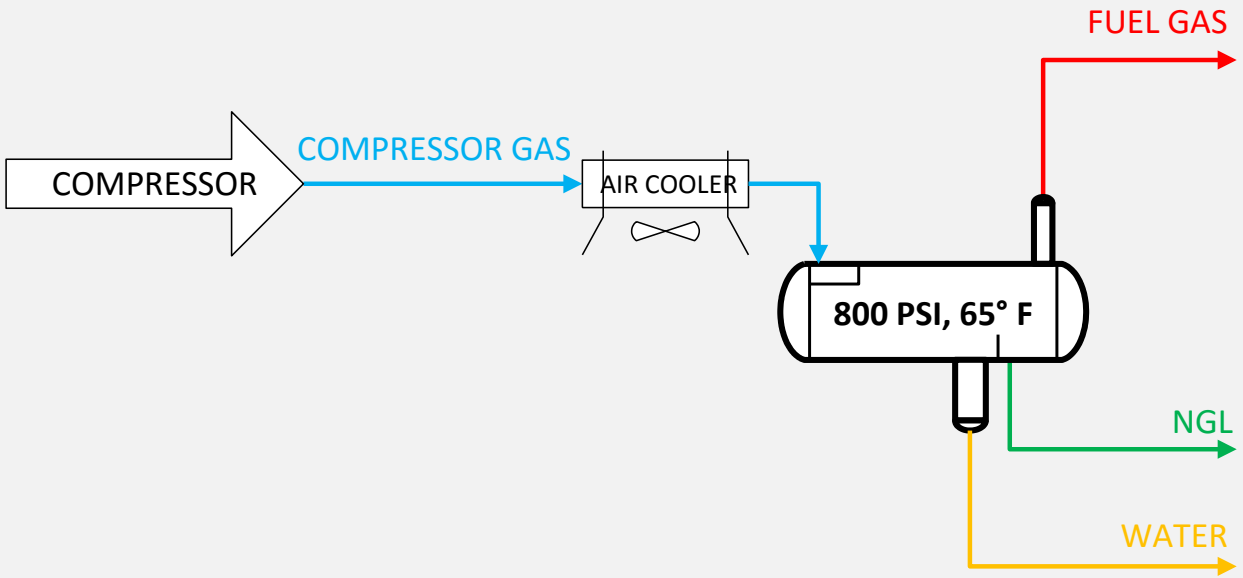


Figure 1: Flaring in the Bakken.

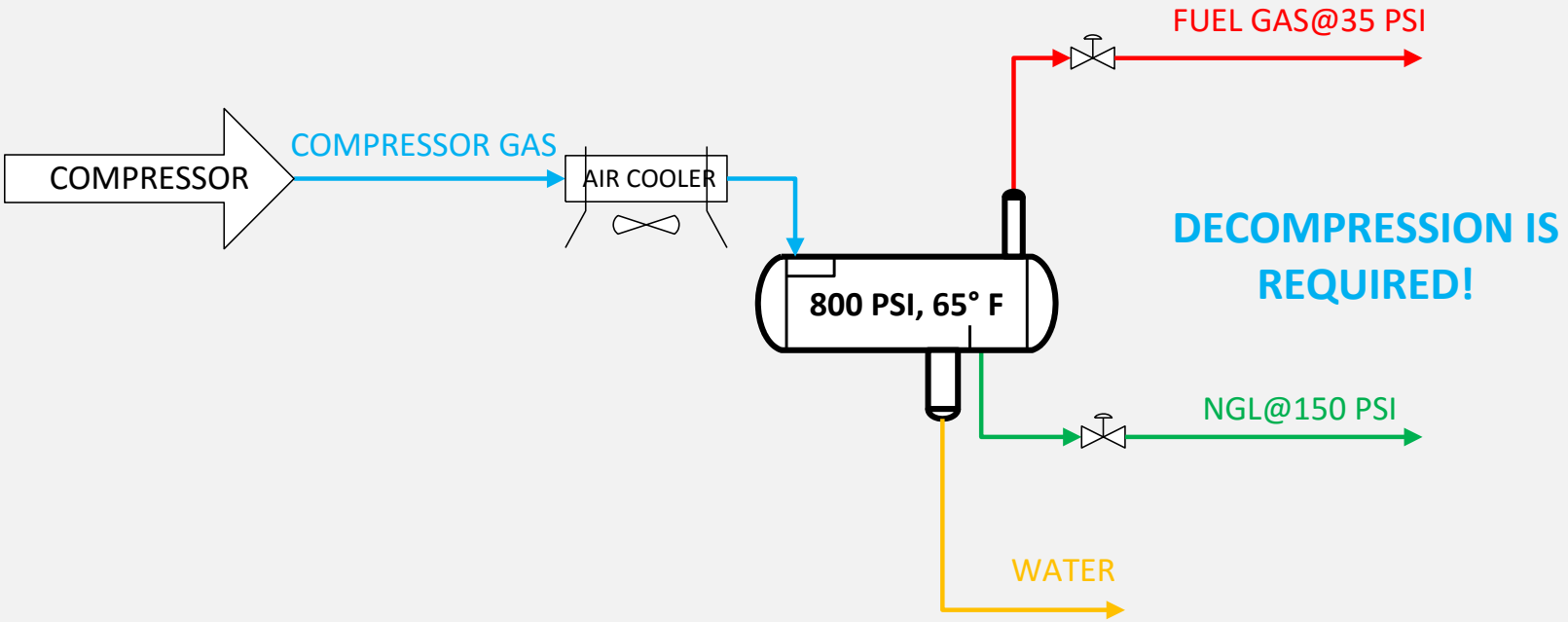
There are several known alternatives to flaring. First, lean natural gas -- gas that has only a small amount of propane and heavier hydrocarbons -- can be used as a fuel for an internal combustion engine that, in turn, drives an electrical generator. The generated electricity can be used for local power or sold to the electrical grid. Second, natural gas can be compressed and sold as Compressed Natural Gas (CNG). Third, natural gas can be converted to liquid fuel including methanol. However, associated gas produced from horizontal drilling in shale basins is rich gas, because the gas contains substantial amounts of heavier hydrocarbons including propane, butane, hexane, heptane and octane. The aforementioned hydrocarbons are known as Natural Gas Liquid (NGL). Rich gas is unsuitable for known flaring alternatives for three reasons. First, the heavier hydrocarbons cause the gas energy content to be too high for internal combustion. Specifically, the high energy content causes internal combustion engines to knock. Second, the high energy content makes the gas unsuitable for CNG fuel. Third, the heavier hydrocarbons in the rich gas interfere with methanol and other liquid fuel chemistry. The NGL Pro process removes the valuable NGL hydrocarbons for sale and distribution while concurrently producing a lean natural gas suitable for all flaring alternatives.

The associated gas with the NGL is currently entirely lost to the flare. Concurrently, environmental pressures are mounting to curtail flaring in North Dakota as well as other parts of the United States. If flaring is indeed curtailed, then drilling in North Dakota will stop.

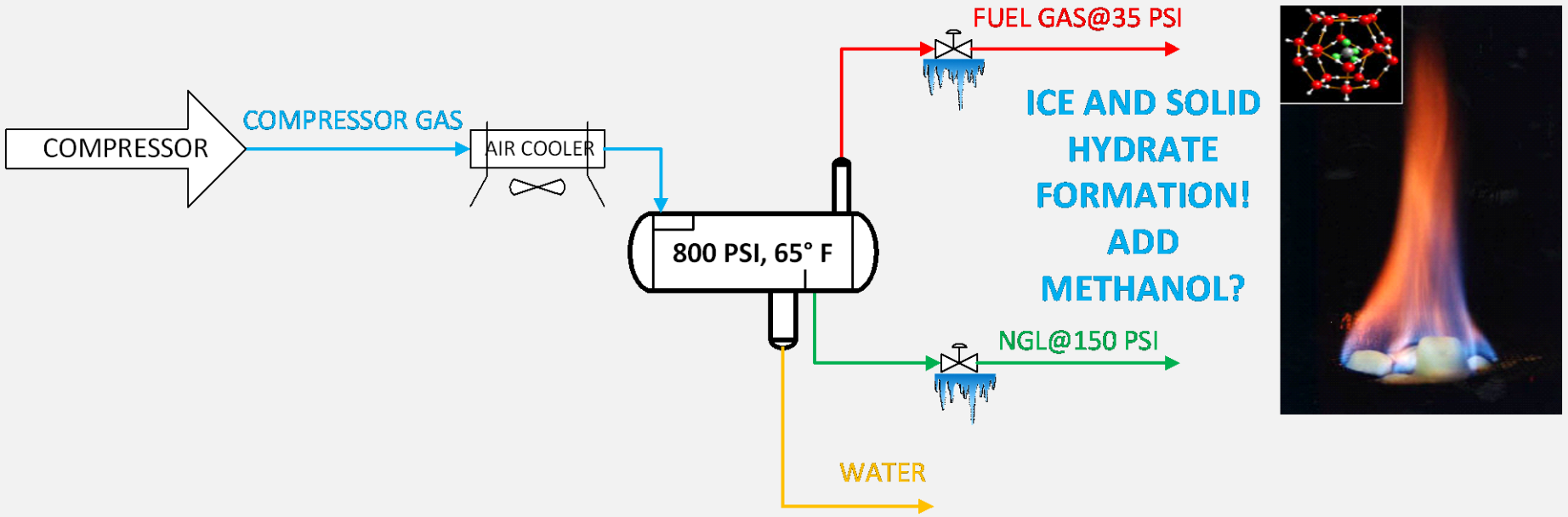
NGL PRO PROCESS DEVELOPMENT
STEP 1: NGL PRO SIMPLISTICLY



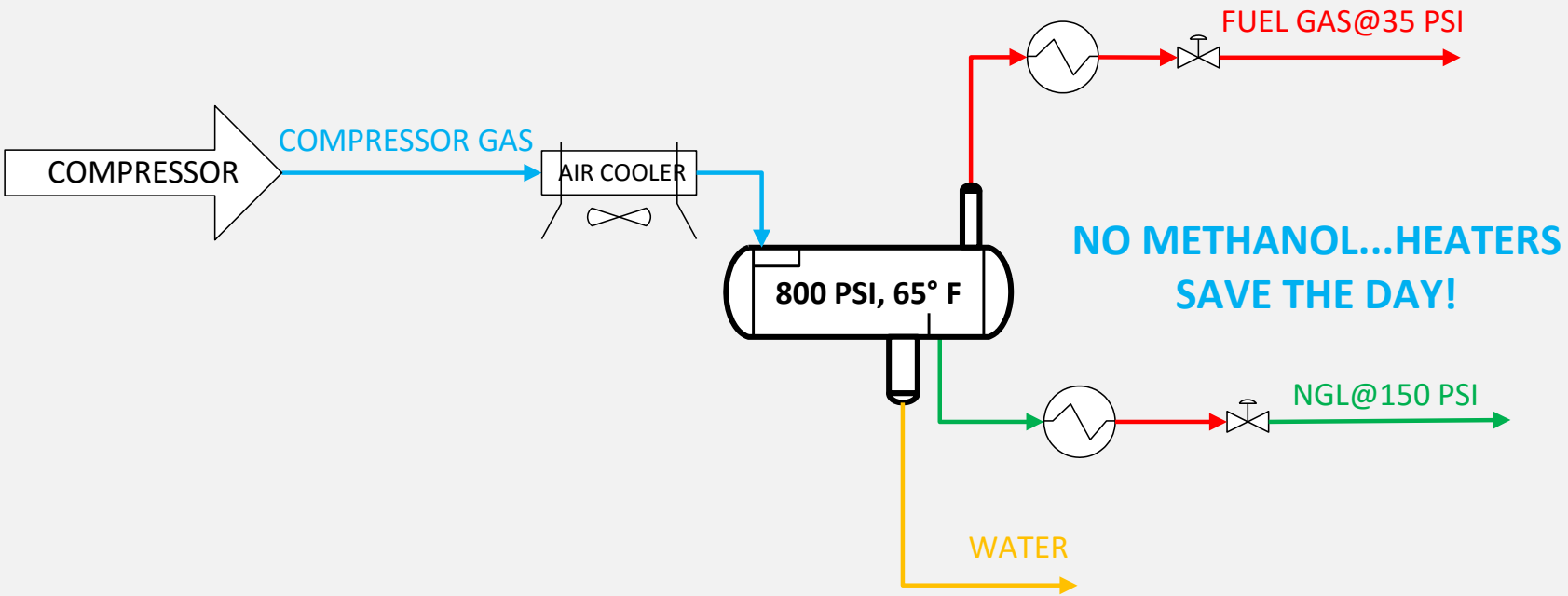
NGL PRO PROCESS DEVELOPMENT
PROBLEM 1: DECOMPRESSION IS REQUIRED FOR STORAGE…



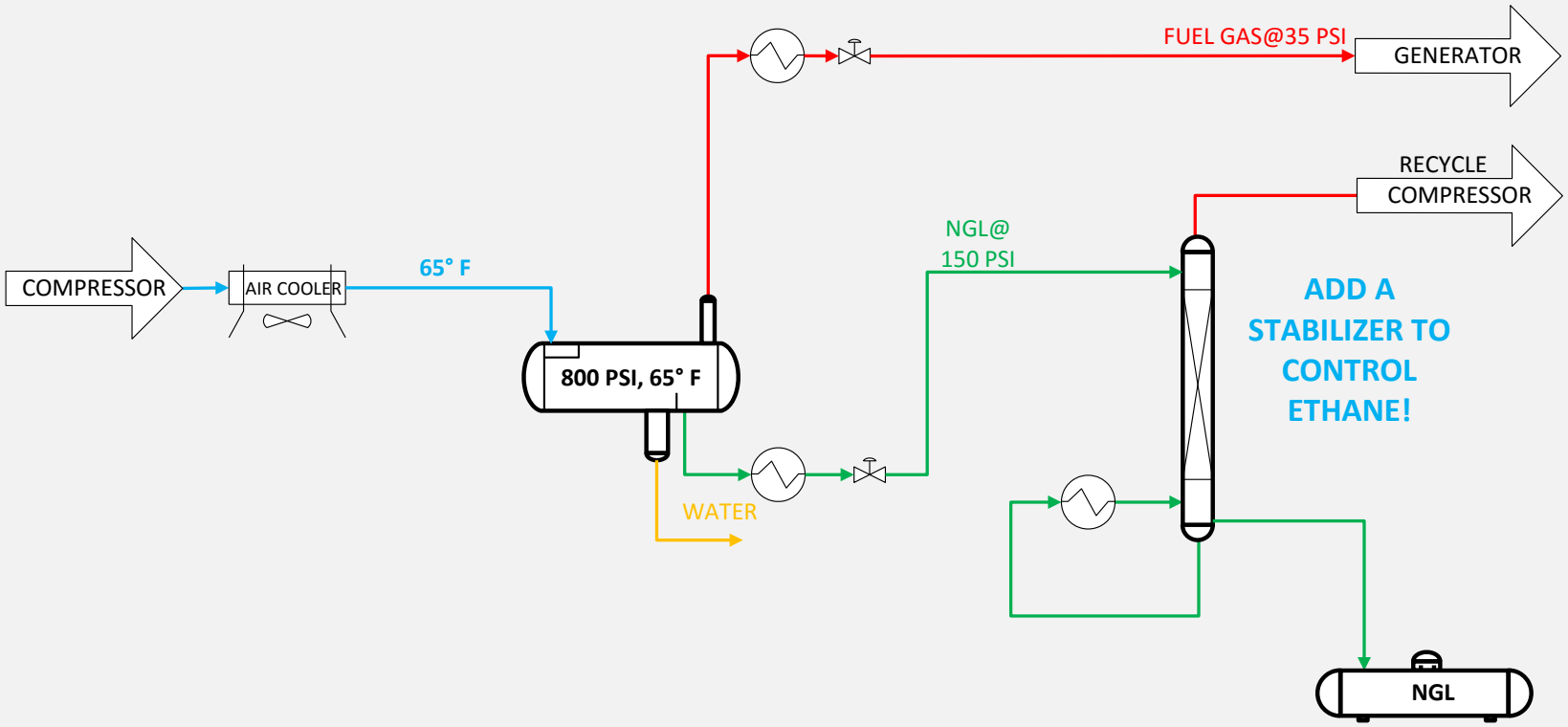
NGL PRO PROCESS DEVELOPMENT
…AND DECOMPRESSION CAUSES HYDRATE FORMATION



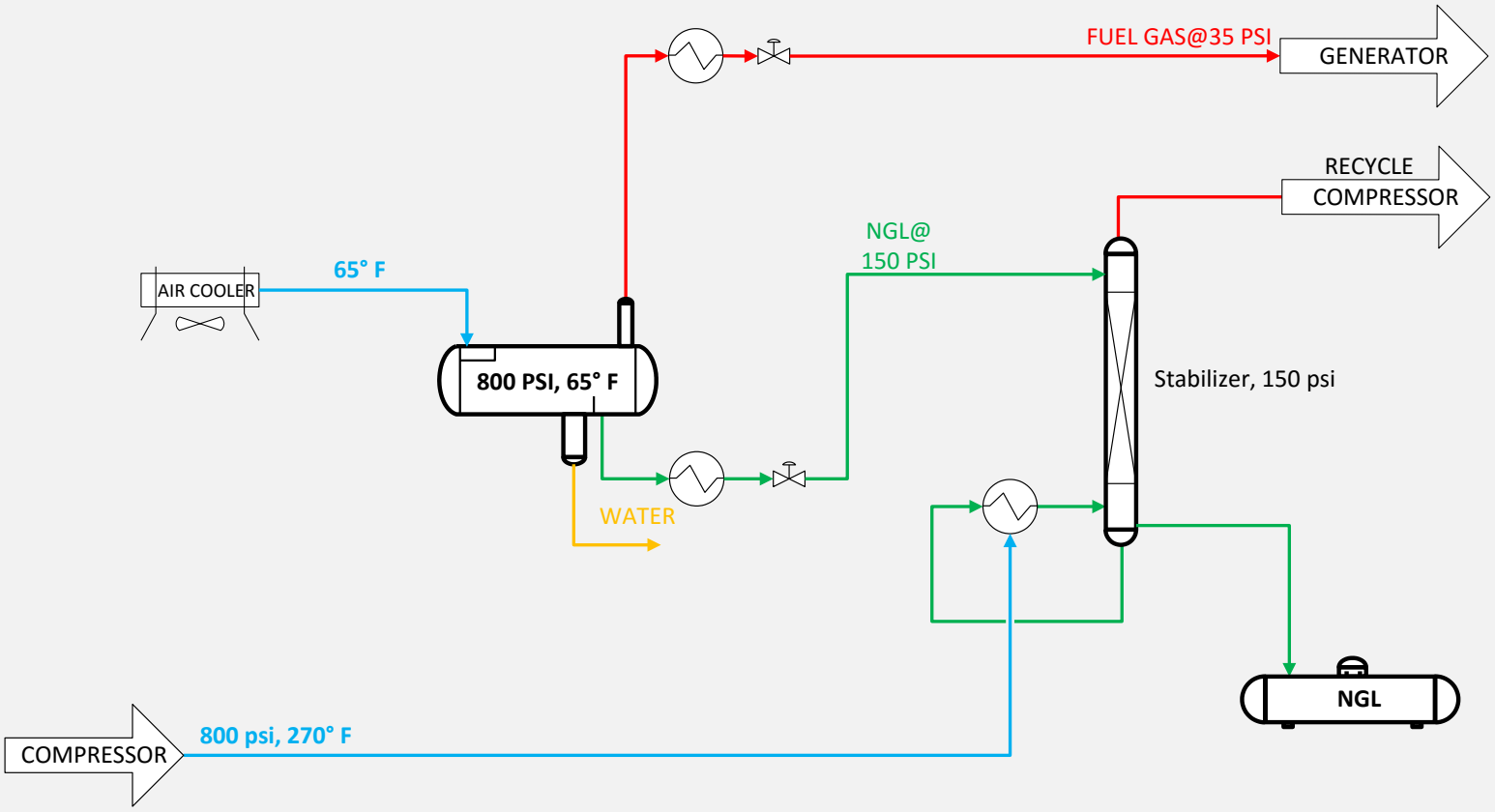
NGL PRO PROCESS DEVELOPMENT
STEP 2: HEAT BEFORE DECOMPRESSION



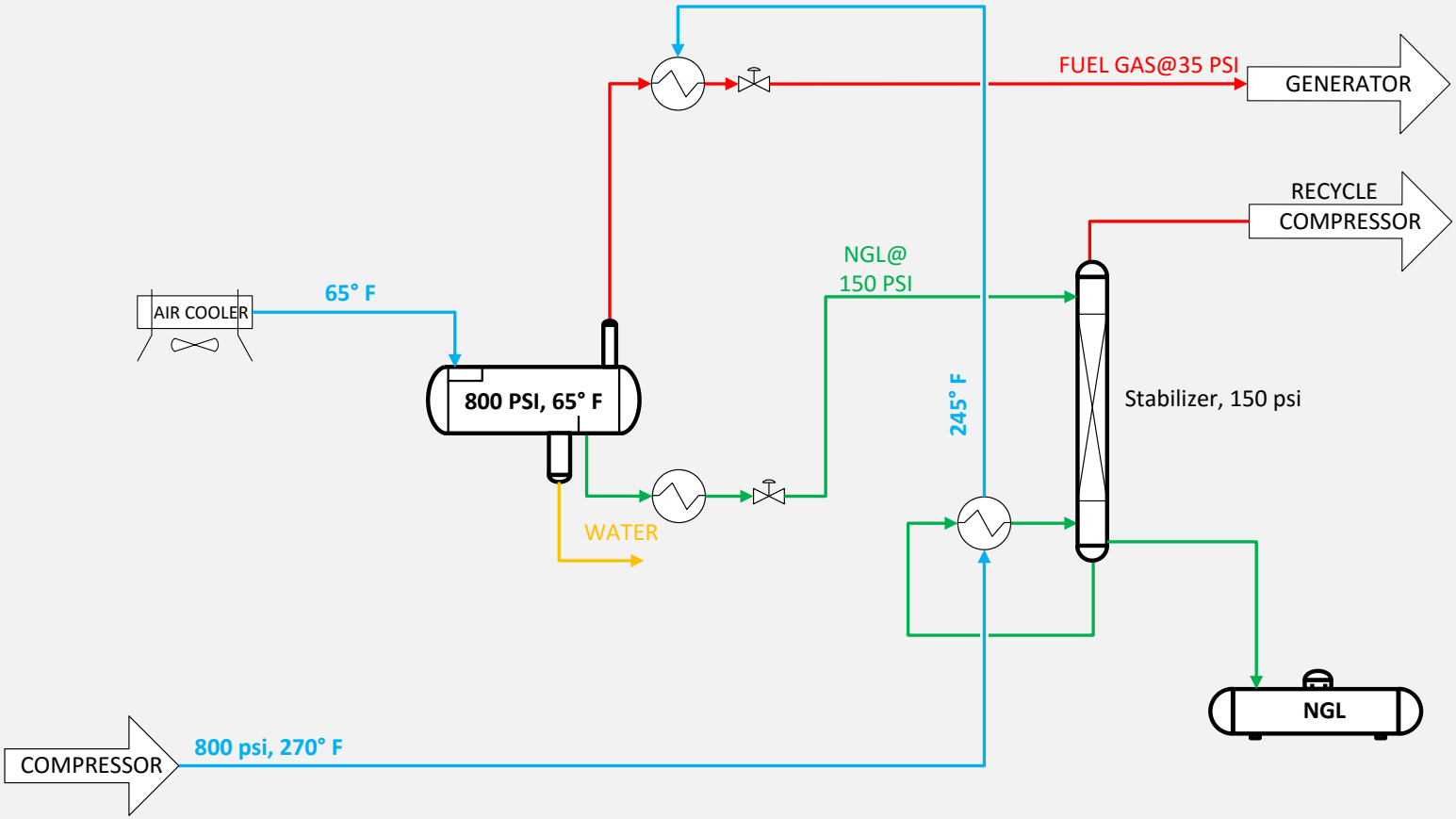
NGL PRO PROCESS DEVELOPMENT
STEP 3: STABILIZE TO REMOVE ETHANE AND LOWER VAPOR PRESSURE FOR SHIPMENT



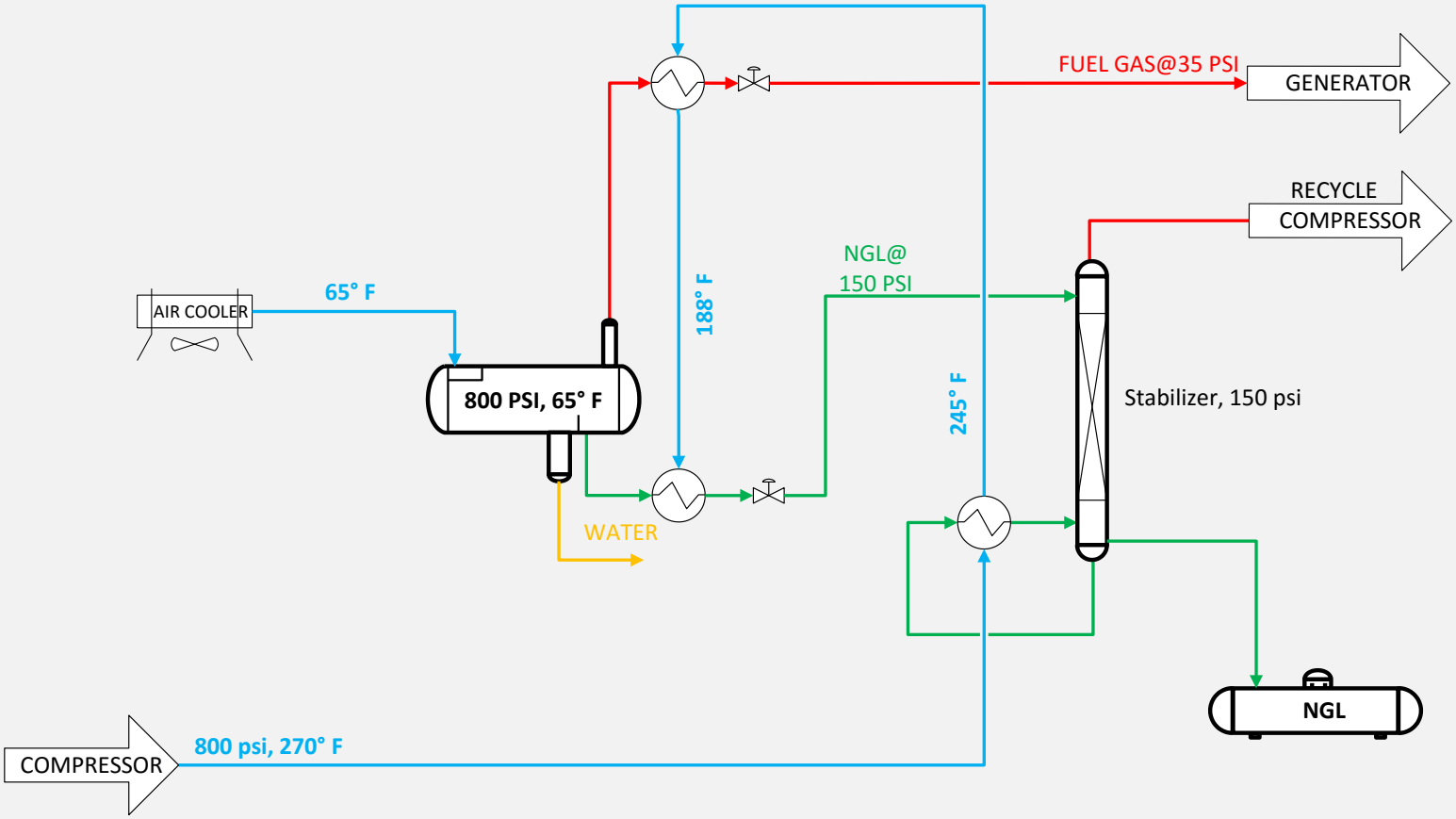
NGL PRO PROCESS DEVELOPMENT
STEP 4: USE HOT, COMPRESSED GAS TO DRIVE THE REBOILER



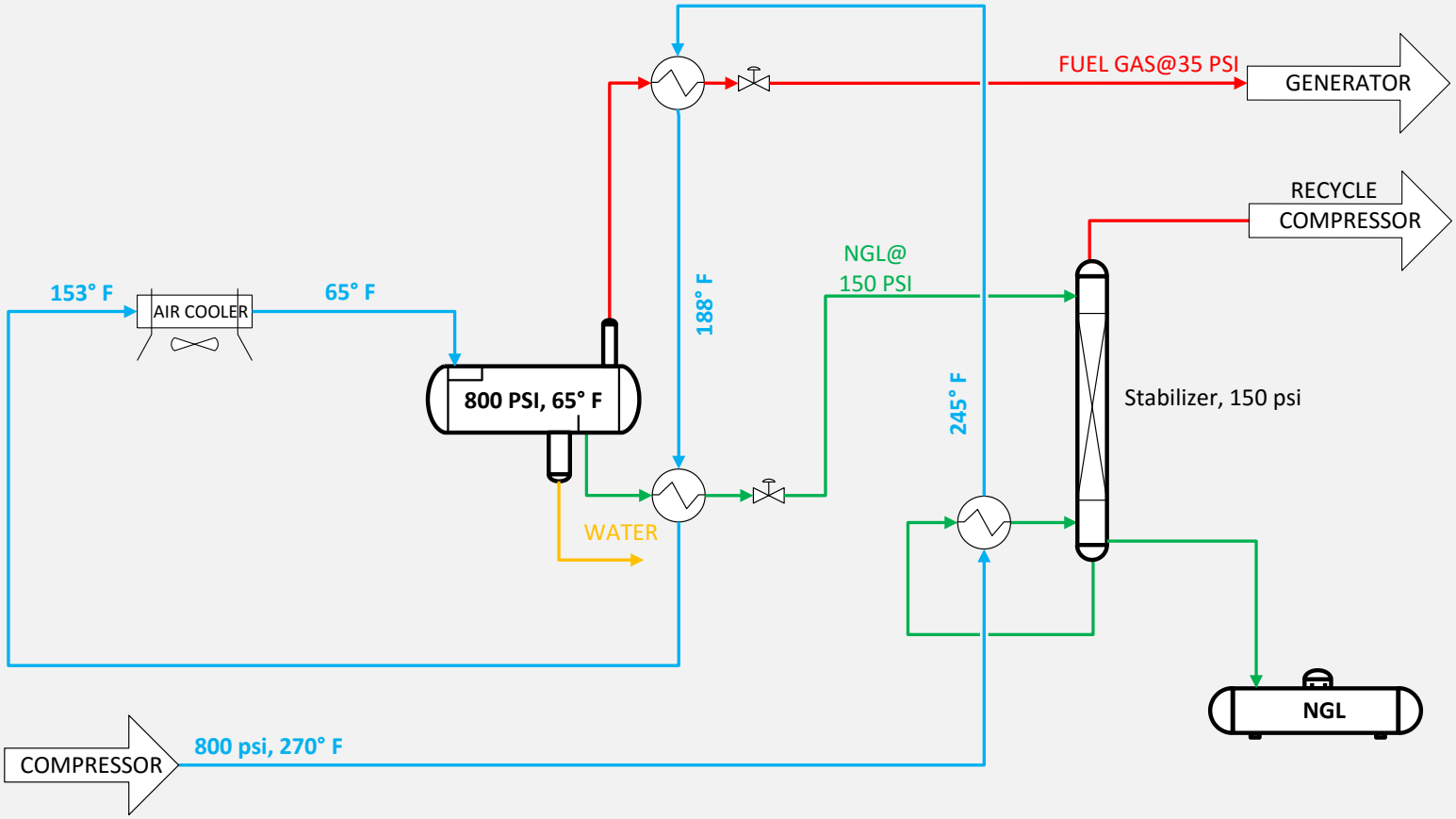
NGL PRO PROCESS DEVELOPMENT
STEP 5: USE HOT, COMPRESSED GAS TO HEAT THE RESIDUE GAS EXCHANGER



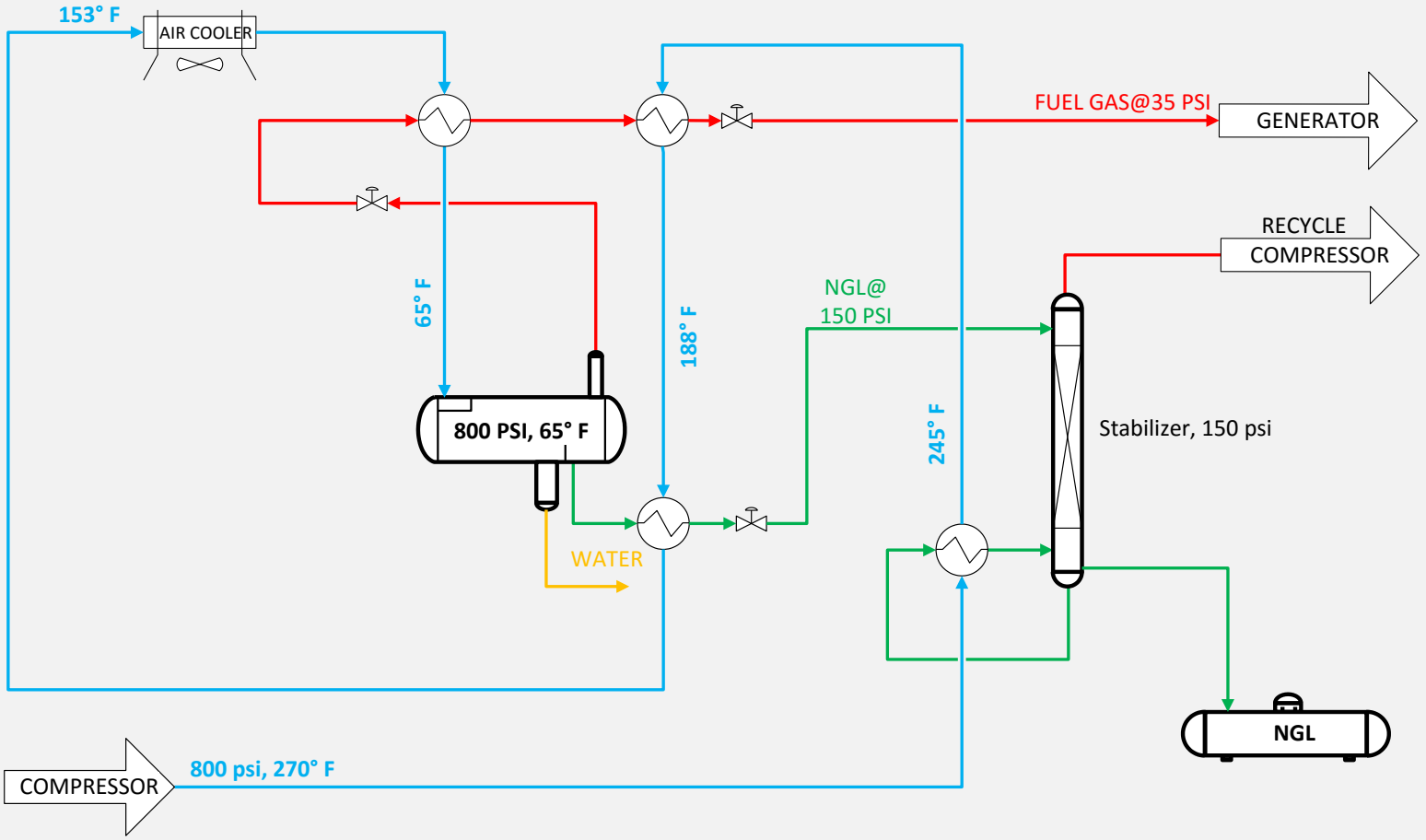
NGL PRO PROCESS DEVELOPMENT
STEP 6: USE HOT, COMPRESSED GAS TO HEAT THE NGL EXCHANGER



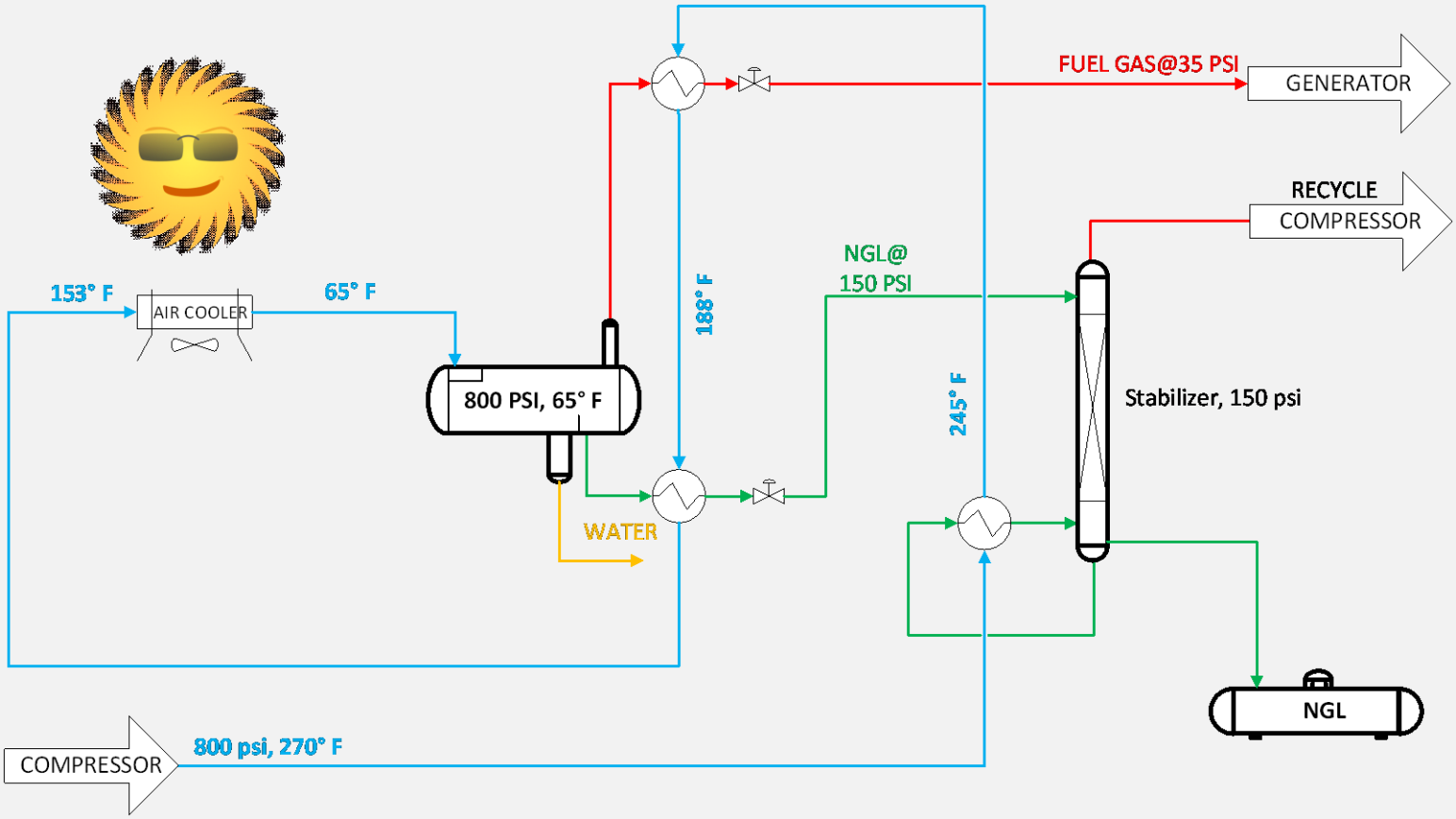
NGL PRO PROCESS DEVELOPMENT
STEP 7: REMOVE REMAINING HEAT IN THE THIRD STAGE COMRESSOR AIR COOLER



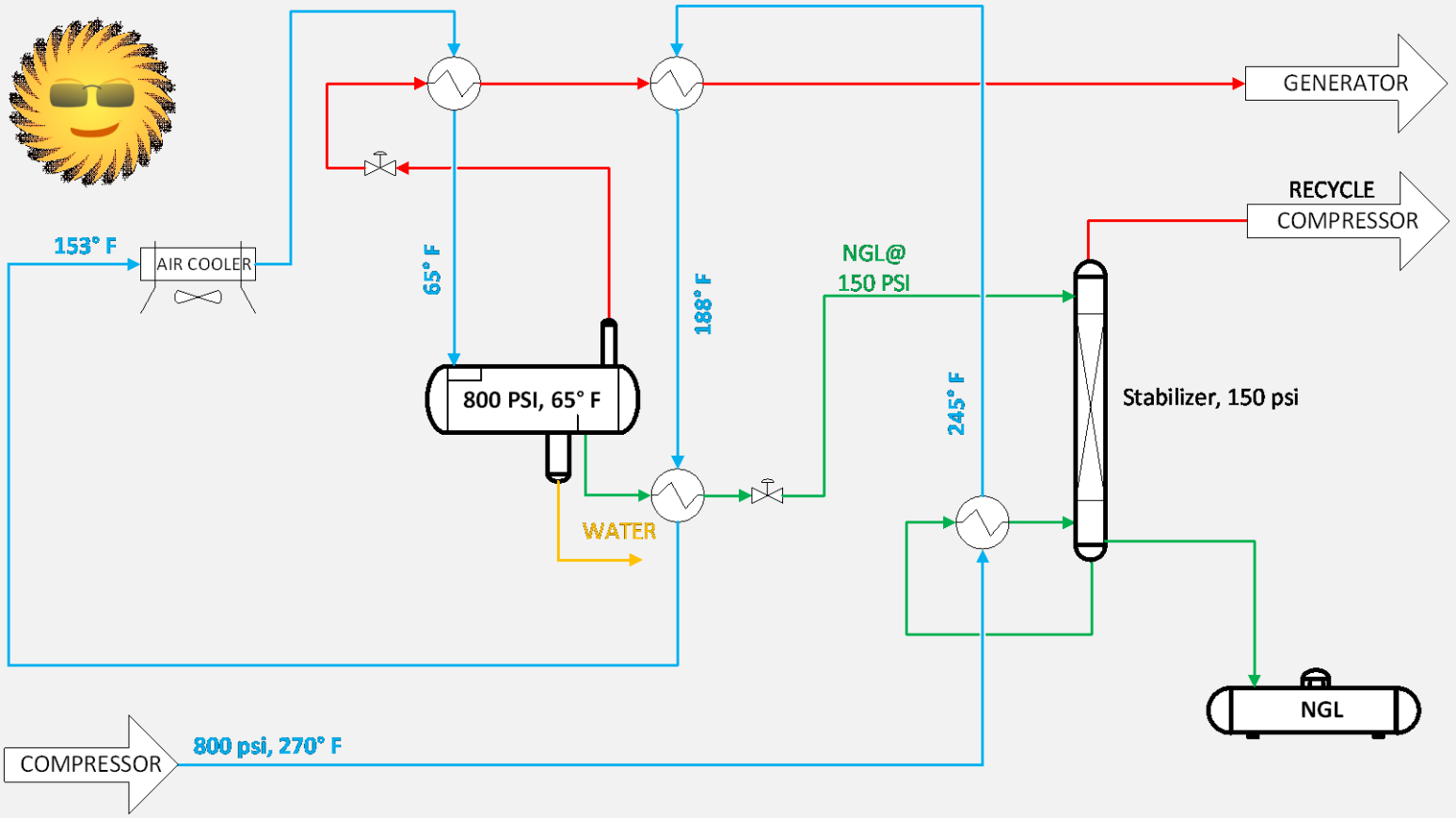
NGL PRO PROCESS DEVELOPMENT
STEP 8: DEPRESSURIZE FUEL GAS FOR GENERATOR IF ELECTRICITY IS DESIRED



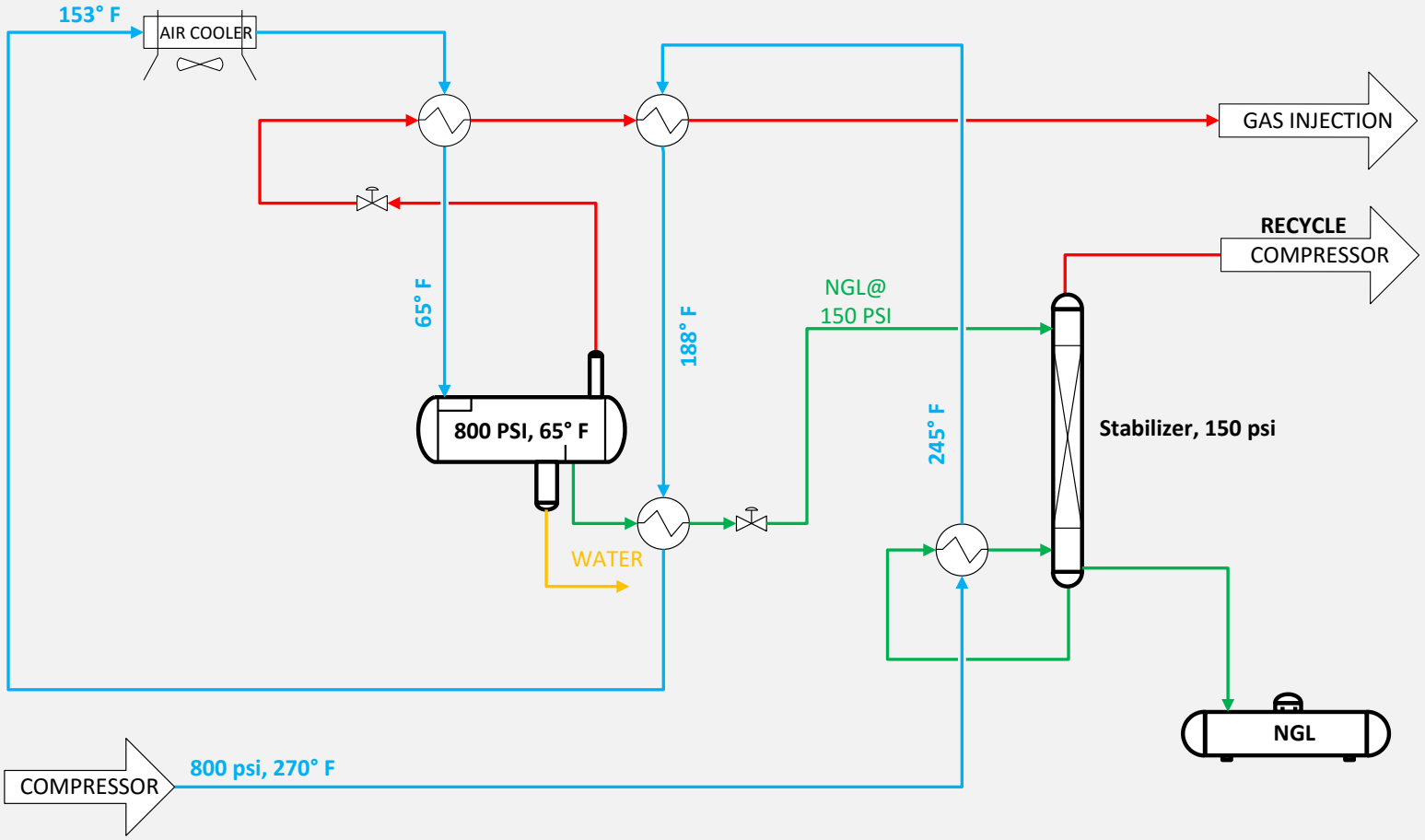
NGL PRO PROCESS DEVELOPMENT
PROBLEM 2: WHAT IF IT IS HOT OUTSIDE?



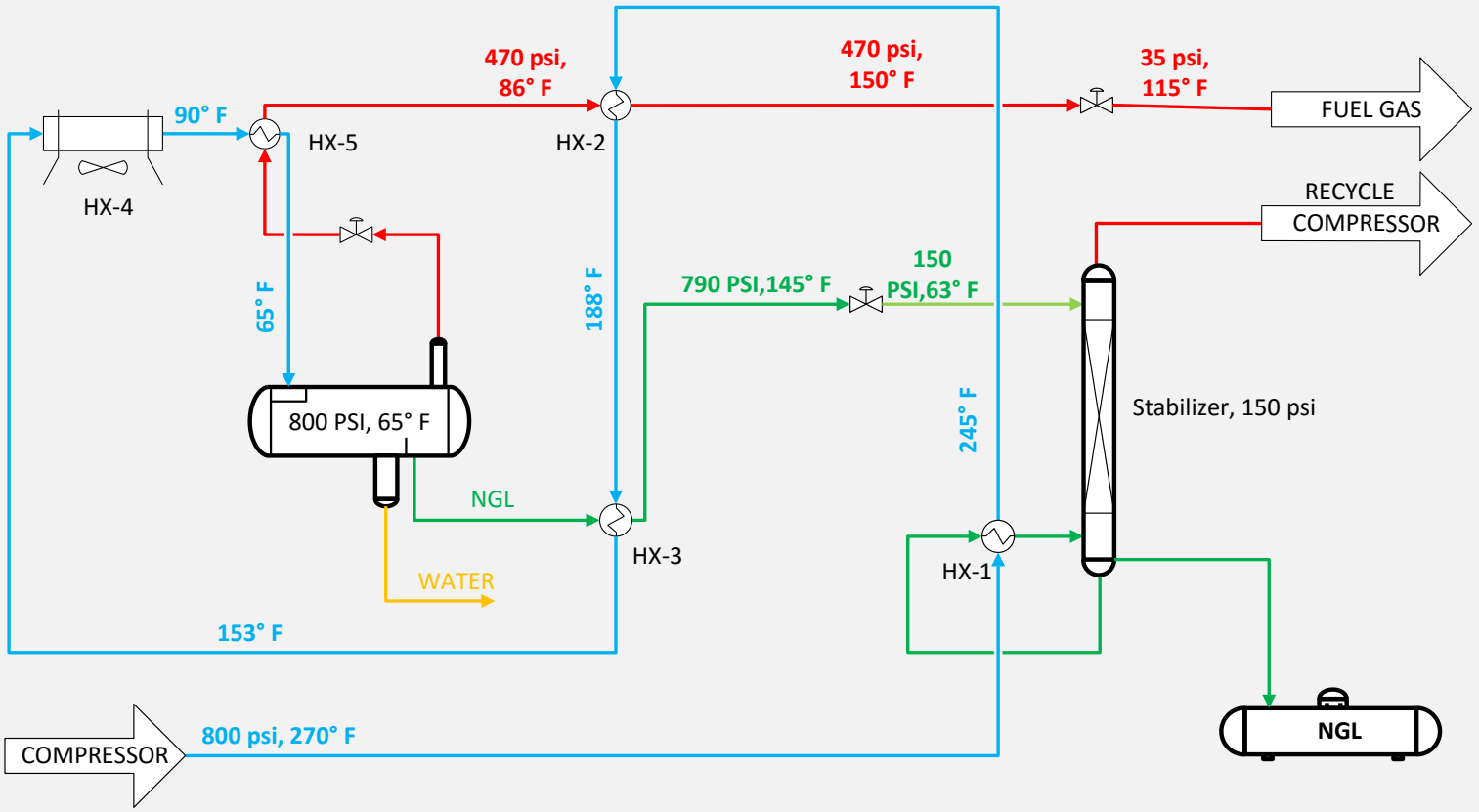
NGL PRO PROCESS DEVELOPMENT
STEP 9: EXPAND THE RESIDUE GAS AND ADD A FOURTH EXCHANGER (OPTIONAL --- FOR HOT CLIMATES ONLY)



NGL PRO PROCESS DEVELOPMENT
STEP 8: DO *NOT* DECOMPRESS RESIDE GAS FOR ARTIFICIAL LIFT



NGL PRO PROCESS DEVELOPMENT
COMPLETE FLOW DIAGRAM WITH OPERATING CONDITIONS

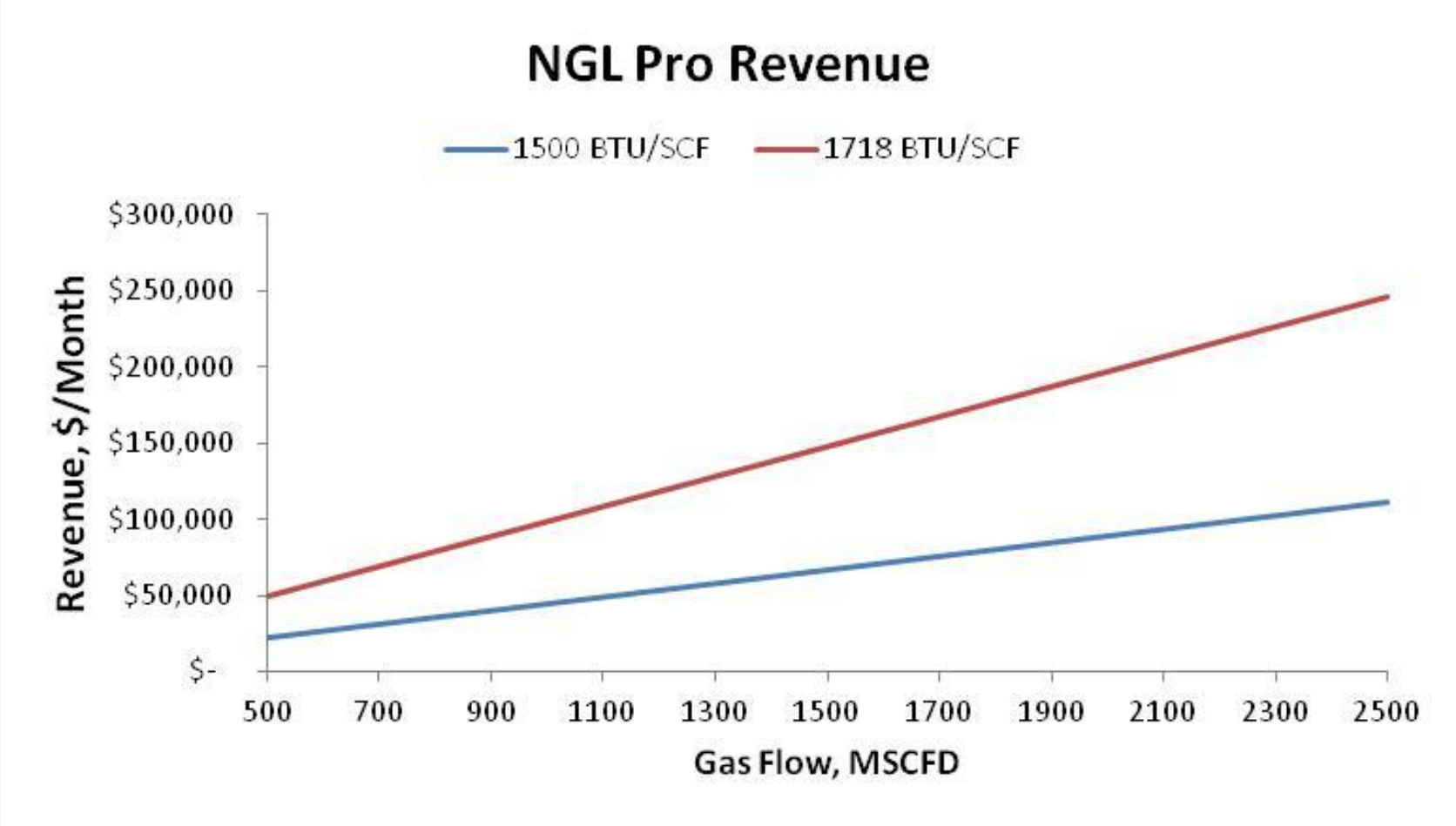


- No expensive refrigeration systems.
- No moving parts.
- No glycol antifreeze.
- No methanol antifreeze.

- Stabilized NGL product for shipment.
- Heat integration reduces air cooling burden.
- Unlimited turndown.

- Fuel gas condition for electricity generation.
- Fuel gas condition for artificial lift.

NGL PRO


NGL Pro Revenue
1500 BTU/SCF
1718 BTU/SCF
Revenue, $/Month
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$-
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
Gas Flow, MSCFD

NO REFRIGERATION OR ADDITIVES ARE REQUIRED

NGL PRO IS A SIMPLE, COST-EFFECTIVE SOLUTION FOR NGL RECOVERY

NGL PRO

REFRIGERATION

NGL PRO

Patent Pending

Ease of Transporting Equipment

Set On Oil or Gas Well Pad

Meets Class 1 Division 2 Safety Standards

Supported by Field Technical Teams

Ideal for Gas Lift

ENGINEERING AND INQUIRIES

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