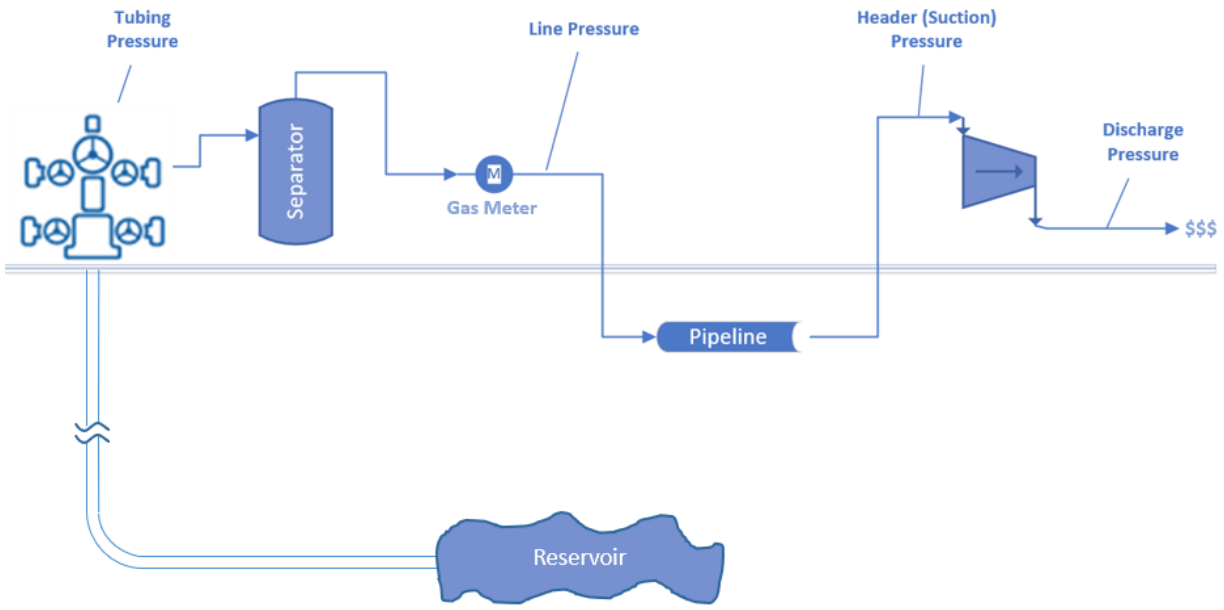
Pig Route Optimization

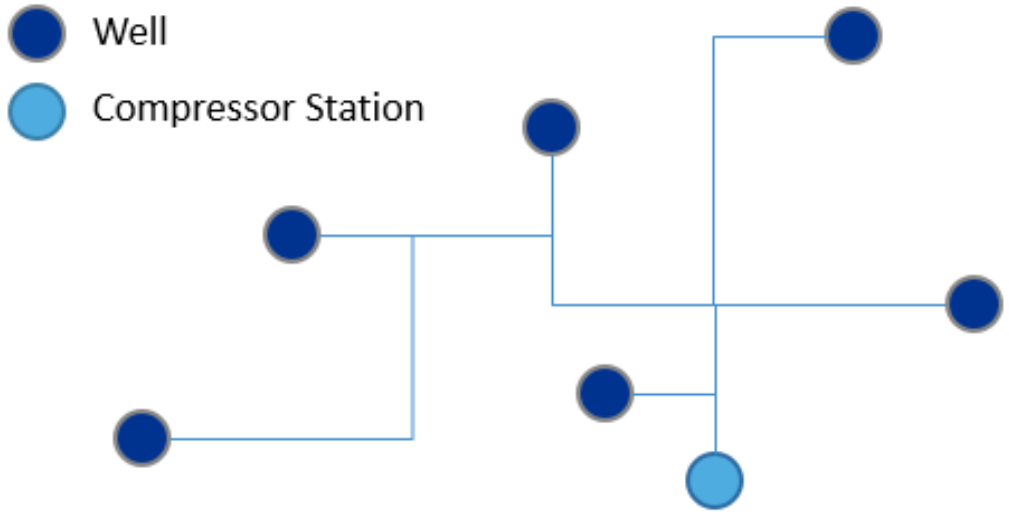
Gas Gathering System

- Natural gas will travel from reservoir (high temperatures and pressures) to well-head via tubing shown in the above image.
- Separator here will separate (water in this case) liquid from the gas and feed it to the gas meter. Gas from several wells will be collected in the common pipeline.
- Several pipelines fed into center processing facility (CPF) or compressor station.



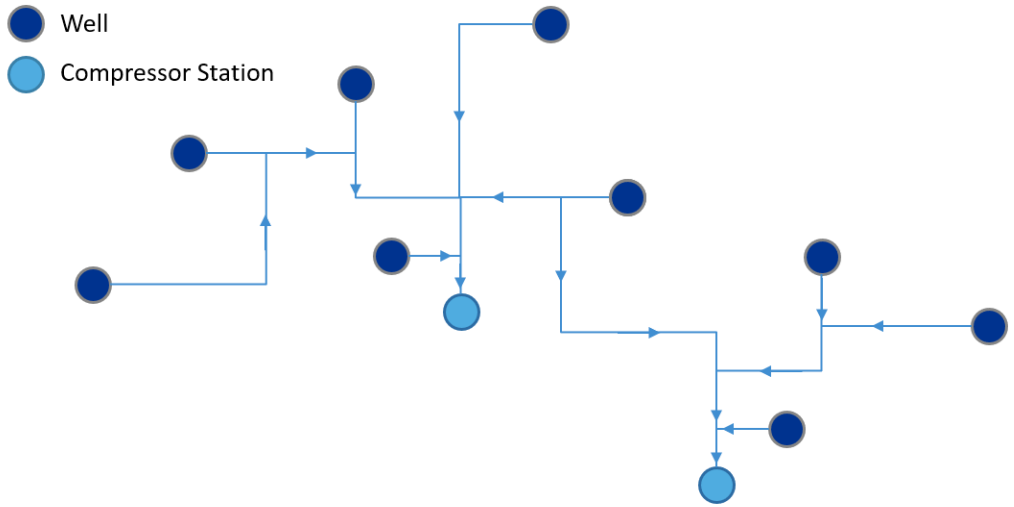
Gas Gathering System

- A typical gathering system has a one-to-many relationship between the wells and CPFs as shown in blank below (many wells per CPF)
- **Line Pressure:** the back pressure exerted on the well, is measured downstream of the gas metering process
- **Header Pressure:** The pressure upstream of the compressor.
- **Differential Pressure:** The required potential energy spend to move the gas from the well head through the gathering system to the CPF.



Gas Gathering System

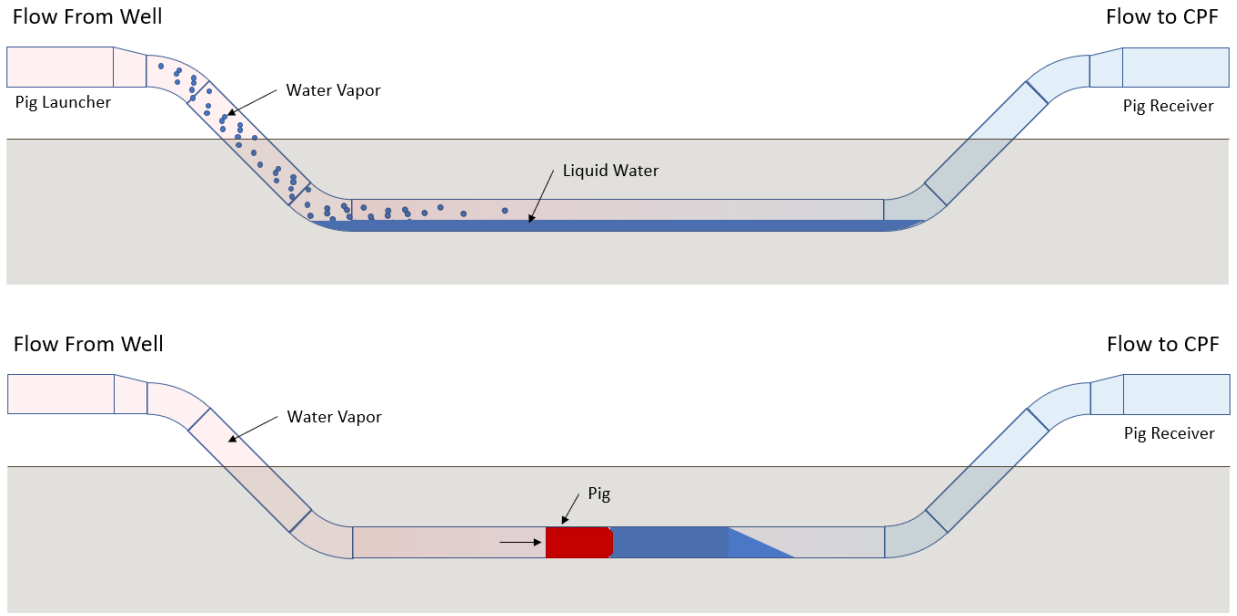
- Gathering system usually is not very typical but consists of very complex network of wells and CPFs.
- There are many-many relationships between wells and CPFs (compressor stations).
- Below is the simplified version of wells, pipelines and CPFs network but in real life scenarios this system can have >4000 wells and >50 CPF stations.
- As natural gas flow from the pipelines, entrained water will drop out of the natural gas and collect in low points of the pipelines.



Pipeline Pigging

- Water collected in the low points of the pipelines will restrict the natural gas flow.
- A process of pipeline pigging is used to remove water collected in the pipelines to restore normal natural gas flow.
- **Pig Route:** Desired path of travel for the pig.
- **Pig Run:** Act of running a single pig.

- Pig routes have a one-to-many relationship with the wells that they affect, i.e., removing water from a pig route would positively affect one or more wells. Note that depending on where the water is along the pig route, some wells may benefit, and others may not.



Data Points for ML Model

- There are four datapoints available for this (This may vary for different oil and gas companies)
  - Well line pressure (at well head)
  - Well gas flow
  - Temperature (not found helpful)
  - Header pressure (at CPFs)
  - Differential pressure (derived datapoint)

- Relationship between line pressure, differential pressure and header pressure
  - LP = dP+HP

- Ultimate objective of any pigging process is to minimize dP (differential pressure) and to maximize well gas flow.

Data Points EDA

There is no restriction in the pipeline:

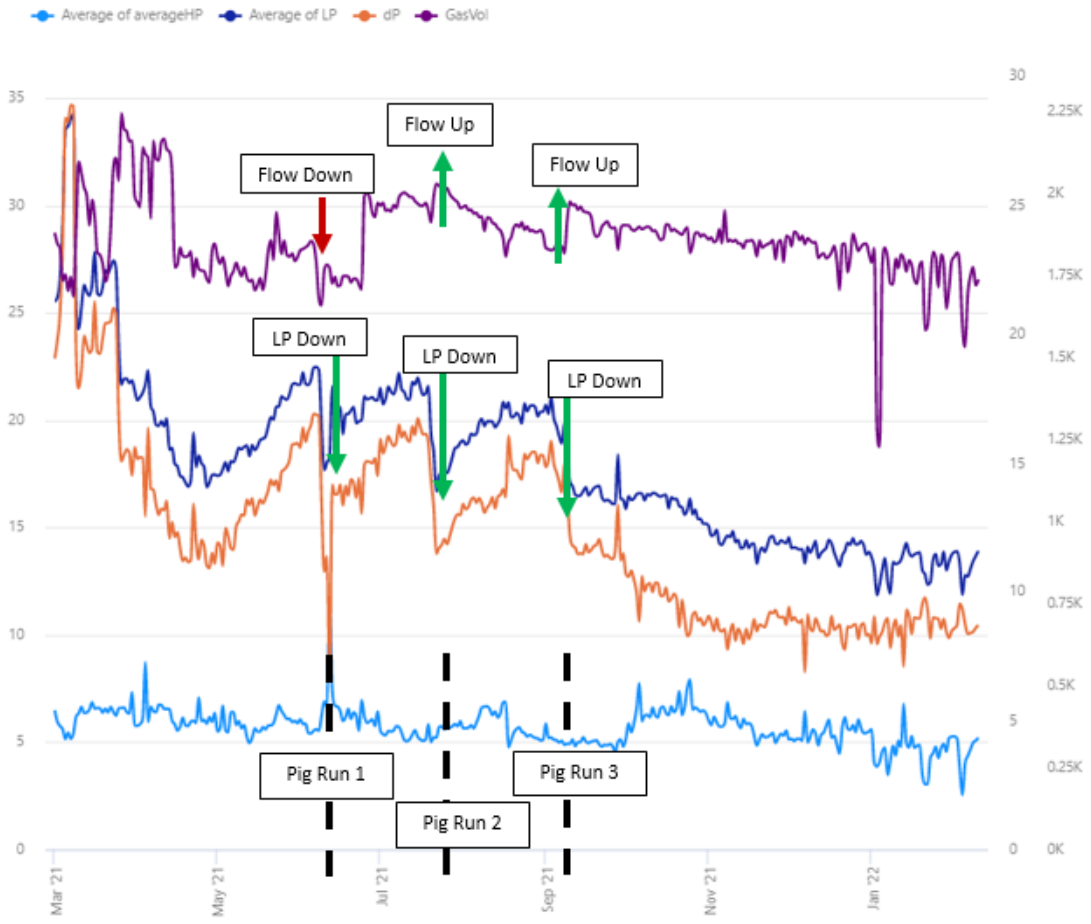
- Line pressure positively correlated to the gas flow. As gas flow increases line pressures increases due to large frictional losses.

There is restriction in the pipeline:

- Line pressure negatively correlated to the gas flow. This will case line pressure to increase and gas flow to decrease.

Data Points EDA

- A decrease in gas flow with increasing line pressure provides opportunities for the pigging.
- A successful pig run characterized by the restoration of the gas flow and reduction in line pressure in the coming days.
- Currently, with traditional methods, operators observe these data points manually and operate pig runs based on assumptions.



Primary Trade-offs and Objective

- Detection of opportunities for the pig runs. (Removing liquid or restrictions).
- Prioritizing pig runs as the resource are limited.
- A false positive may cause us 1000$ in pig material, human resource and impact production from zero to 10,000$ dollars.

Machine Learning Model for Pig Route Optimization

- Blue bars show confidence in the pig runs for this pig route.
- Red vertical lines are the actual pig runs.
- Line plots are line pressures for the wells attached to this pig route.
- Background processes will calculate these confidence values and provide early warnings for pig runs.
- There will be no need for manual intervention by the operators.

Thank You