Hackathon Help Sheet

Figure 1: A calm day at sea for the Alba North platform

Process Overview

The Alba platform is a typical North Sea design. It produces mostly oil, with some gas and a lot of water. All the fluids come into the three first stage separators. This is where virtually all the gas is separated, and bulk separation of oil and water occurs. The gas is then compressed to feed the main turbine which generates power for the platform. Only gas from the first stage separators is compressed, everything else is flared. The oil is further degassed and processed to export specification. The water is cleaned before being discharged into the sea.

When fluids are removed from the reservoir the pressure falls, so to maintain this pressure (and so production) seawater is injected back into the reservoir. There are three main seawater lift pumps which supply seawater that is deoxygenated and then injected at very high pressures via the five water injection pumps. Seawater is also used as a cooling medium for various pieces of equipment.

There are two turbines on the platform: John Brown (JBT) and the Solar. The names are manufacturers' names. The JBT is the main turbine and in normal operation is the only one online. The Alba field doesn't produce enough gas to support the power demand and so gas is imported from the nearby Britannia field. This gas can only supply the JBT due to the piping configuration. The Solar is used when the JBT is undergoing maintenance. It is a much smaller unit and can only support gas compression and one water injection pump at the most. Both turbines can be run on diesel fuel. However, this is expense to purchase and produces more greenhouse gas emissions per watt of power than fuel gas. Diesel is only used when the gas compressors are unavailable. All the equipment (pumps and compressors) is electrically driven.

The platform has a flare, which is primarily a safety device to remove all hydrocarbon gas in an emergency. The design of the flare means it must continuously burn a small amount of gas to have it available. The flare has a high pressure (HP) and a low pressure (LP) system which serves different parts of the process. Any gas from vessels other than the first stage separators is sent to the LP flare. The HP flare is used when shutting down and for pressure control on the gas compression system.

A process flow diagram is available.

Units of measure

For historical reasons, the oil industry uses a mix of units, hopefully I can explain the important ones here for reference:

- Liquid flow rate:
  - Measured in barrels – This is a US oil barrel equivalent to 42 US gallons.
    - 1 barrel = 0.158987 m^3.
    - Flow rates are often in barrels per day (bpd)
    - bwpd (w = water) bopd (o = oil).
- Gas flow rate:
  - Expressed as standard cubic foot per day/hour, written as scf/d.
  - Multipliers used: M = 1,000, MM = 1,000,000. E.g. 4 MMscf/d = 4 million scf/d.
  - This is a measure of the number of molecules. The standard in scf refers to a certain temperature and pressure at which the gas is when the number of molecules are counted. As gas is compressible, more pressure can be applied and the volume those molecules takes up will get smaller and smaller.
  - Standard cubic metres (Sm^3) is also a measure, but the conversion is not volumetric (although very close):
    - 1 Sm^3 = 35.295 scf
  - If you're lucky the meter measures in kg/day
    - 20.62 * MMscf of gas = tonnes of gas
- Power:
  - Measured in Watts (or MW for 1 million watts), this is the load on a unit, and is equivalent to Joules/second (J/s).
    - Energy is measured in Joules but in power situations is measured in Wh, or kWh or MWh.
    - A 4 MW pump will consume 4 MW x 24hrs = 96MWh per day.
  - AC power is more complex than DC so to convert amps measured to power consumed:
    - Active Power = Current * Voltage * √3 * Power Factor
    - Power factor can be assumed to be 0.95
  - Large machines have tags call FLC% - Full load current % (from 0-100%). This is a scaled tag representing how much current the motor is drawing compared to its design rating. This % can be multiplied by the design load rating in kW to get the power consumed by the machine. See Useful Tags below.

Greenhouse Gas Emissions

When hydrocarbons are burnt, energy is released – this is the energy that is used to generate electricity. However, carbon dioxide is also produced, and the amount of which depends on the composition of the gas. Alba and Britannia gas have different compositions, so burning a kg of one will generate a different amount of CO_2 than the other. However, it's a detail that can be refined later and for now can be ignored. Greenhouse gas emissions also include other gases, such as methane and other unburnt hydrocarbons. Typically, everything is converted back to tonnes of CO_2 equivalent, or tCO_2e or just tCO_2. Non-CO_2 gases are a tiny fraction of the total from the platform so can be ignored.

The UK has an emissions trading system whereby producers are allocated a certain number of CO_2 credits and then must purchase extra if they need them. For simplicity we can assume all CO_2 has to be purchased.

For ease of implementation here are some conversion factors that can be used:

- 1 tonne of gas burnt produces 2.656159 tonnes of CO_2.
- 1 tonne of diesel burnt produces 3.2 tonnes of CO_2.
- Density of diesel is 854 kg/m^3
- 1 tonne of CO_2 costs €25

Electricity Generation

As stated, all the equipment is driven by electric motors and the power is generated centrally by the main turbine. For interest, some platforms have dedicated turbines that drive pumps or compressors directly – i.e. the all share the same rotating shaft.

If I consume 1 MWh and generate 0.6 tonnes CO_2 by running two pieces of equipment, I need to allocate that CO_2 back to each pieces of equipment. Ideally, I have the power draw for each unit then I can ratio it in some way. However, I may not and have to infer it from other information – perhaps by a balance of power or flow or current draw. This allocation may be different if I'm running more equipment and my turbine is more efficient.

Each turbine has different efficiencies at different loads and fuel types. A 10 MW load on the JBT will generate a different amount of CO_2 than 10MW on the Solar. Likewise, 20 MW load on the JBT will generate less CO_2/MW than when operating at 10 MW. Ambient air temperature effects efficiency of the turbines as well.

Flared gas

There is a continuous purge through the flare system to ensure oxygen doesn't enter the pipework, and to keep the flare lit. An unlit flare means gas is just vented and this has a much greater GHG intensity (and therefore environmental impact) than CO_2.

The gas compression system's pressure is controlled via valves that open to the flare. Each of these valves is part of a control loop trying to maintain the pressure to a certain value. If the pressure is too high, then the valve opens and relies the pressure to the flare. The amount the valve opens can be related to the output signal of the controller (*.OP tag). Valves are different sizes and designs, so one valve open 50% can have a different capacity to another at 50%. It begins to get complicated if one tries to compute the mass rate through the valve based on its opening. It would be ideal if the contribution to the flare can be assigned based upon historical data.

There are meters at the end of the flare just before the gas is burnt.

Recycles

A common design feature for equipment like pumps and compressors is to have a recycle stream, with a recycle valve that controls the flow. These are used for start-up and as a protection for the unit, e.g. preventing a pump from running dry. A consequence of this is that the energy put into the fluid to increase its pressure has been wasted as this pressure has been reduced and the fluid is fed back to the front of the pump again. Therefore, if the recycle valve is open, additional CO_2 is being generated that is potentially adding no useful value.

Sundries

- Sometimes 100% means 100% open and sometimes it means 100% closed
- ~73% of emissions are fuel gas, ~22% is flare, the rest is diesel.
- HP flare is most of the flared gas. There is very little to change on the LP flare system.

Example use cases

Here are some ideas/questions to get you thinking:

- Dashboard detailing emissions and costs for each unit
- Calculates an opportunity score of today's performance compared to the best possible
- Checking for increased emissions per unit over time, e.g. degradation of performance
- A calculator tool that predicts emissions based upon what units the user selects to be online, and what fuel type is burnt
- Are there operating modes that have better emission performance than others?

Useful Tags

The PnID tool has many tags for the facilities, below are some extras that relate to the power consumption on the platform.

	Equip	Capacity	PI Tag	
Supply	Number	kW	**Load**	**Fuel Type**
John Brown Framo 6	Z-5101	35000	ALB-JI_52402.PV	ALB-XI_51004.PV
			Gas Rate: ALB-FI_27905.PV Diesel Rate: ALB-JB_G1.FQLM1	
Solar Mars	Z-5110	10000	ALB-JI_52802.PV	ALB-XI_51800.PV
			Gas Rate: ALB-FI_27904.PV Diesel Rate: None	
11kV Board Users			**FLC%**	
WI Pump A	P-2302A	4900	ALB-FLC_P2302A.PV	
WI Pump B	P-2302B	4900	ALB-FLC_P2302B.PV	
WI Pump C	P-2302C	4900	ALB-FLC_P2302C.PV	
WI Pump D	P-2302D	4900	ALB-FLC_P2302D.PV	
WI Pump E	P-2302E	4900	ALB-FLC_P2302E.PV	
SWLP A	P-2102A	1220	ALB-FLC_P2101A.PV	
SWLP B	P-2102B	1220	ALB-FLC_P2101B.PV	
SWLP C	P-2102C	1220	ALB-FLC_P2101C.PV	
Gas Comp A	Z-0801A	2380	ALB-FLC_K0801A.PV	
Gas Comp B	Z-0801B	2380	ALB-FLC_K0801B.PV	
Export Pump	P-0521S	280	ALB-FLC_P0521S.PV	
Export Pump	P-0521	280	ALB-FLC_P0521.PV	
Coalescer Water Pump	P-0321	90	ALB-FLC_P0321.PV	
Coalescer Water Pump	P-0321S	90	ALB-FLC_P0321S.PV	
Coalescer Water Pump	P-0322	90	ALB-FLC_P0322.PV	
Test Seperator Pump	P-0401	110	ALB-FLC_P0401.PV	
Clean-up Separator Pump	P-0402	110	ALB-FLC_P0402.PV	

11kV Users			**AMPS**	
Accommodation	ET-5201		ALB-II_52423.PV	
General Service 1	ET-5202		ALB-II_52415.PV	
General Service 2	ET-5203		ALB-II_52417.PV	
Essential Services	ET-5301B		ALB-II_52431.PV	
Drilling 1	ET-7601A		ALB-II_52433.PV	
Drilling 2	ET-7601B		ALB-II_52425.PV	

- WI: Water injection
- SWLP: Seawater lift pump
- Gas Comp: Gas Compressor

Try searching for PI tags with the same numbers (usually represents instrument or equipment ID), you may find there are daily totals or averages etc. that are already calculated.

For Solar turbine there's no PI tag that reports the diesel consumption. The following design table can be used to estimate it:

Load (MW)	Diesel Usage (m3/d)
10	78
9	69
5	52
0	25