OPTIMIZING HYDROCARBON and ENERGY MANAGEMENT IN UPSTREAM OIL AND GAS OPERATIONS

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The production of oil and gas employs a highly developed and sophisticated set of technologies to efficiently move hydrocarbons from sub-surface reservoirs into various product value chains. Despite all the developments that focus on recovering the bulk of hydrocarbons, there still remains widespread hydrocarbon loss either due to release at the production site or suboptimal monetization in downstream processing.

Hydrocarbon losses can occur as an economic trade-off, as a result of poor or overly complex operations or simply because projects are developed without enough consideration of the broader context in which they operate. Even in well designed processing facilities there may be inflexibility and sub optimal processing schemes that result in lost opportunities.

In all cases, the value of lost hydrocarbons has a measurable economic impact. Working to monetize even a small fraction of these lost hydrocarbons represents an opportunity for significant financial return.

Hydrocarbon Management

Good hydrocarbon management requires a systems approach both in the sense of ensuring that process technologies are selected and implemented with the whole processing system in view and also in the sense that each project must be placed in its correct context in the larger system that is the entire marketplace.

Good hydrocarbon management also requires a full understanding of what is in the raw products that are being extracted – both desirable and undesirable. In modern world-class organizations, a good amount of detailed information is generally available somewhere in the upstream operations and the best practice is to make sure these details do not get lost further along the project planning process.

Good hydrocarbon management means finding a home for all these components – including the contaminants. And this may require thinking outside more conventional or historical paradigms; but always with a systems view. For a particular project, the decision to separate a component into a purity product or leave it as part of a mixed product will depend on where the project fits in the larger system. Finding a home for everything inherently leads to better environmental outcomes.

Finally, effective hydrocarbon management requires an understanding of the markets and how they change in response to events of all kinds. This includes shifts in the supply and demand for products as other industry participant's complete projects of their own.

At its simplest, good hydrocarbon management means making sure existing processes and equipment are operating as efficiently as the design allows and following a process of continuous improvement to maintain and improve efficiencies. But looking at existing facilities and new projects as part of a whole system with an eye on finding a home for all the components is perhaps not always as easy to do as it is to talk about – real projects often require real trade-offs.

Selection Criteria

There are a number of factors that have an impact on the selection of oil and gas processing technologies. Upstream and downstream factors both influence the selection of midstream processes as shown in Figure 1. The decisions made will affect operating flexibility due to the complex interrelationships and relative uncertainties among the factors.

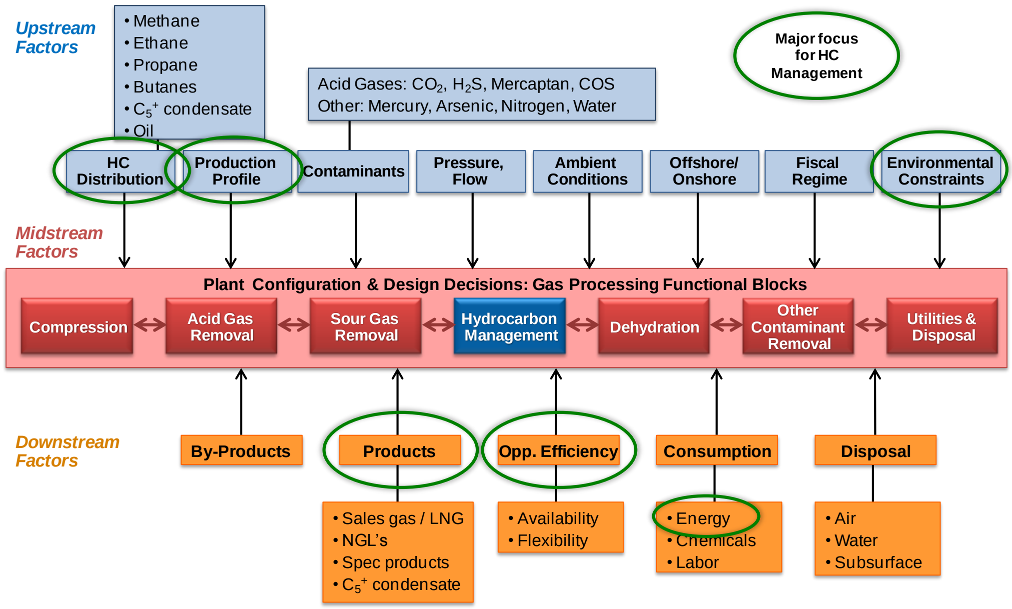


Figure 1: Key decision criteria for oil and gas projects

Upstream factors that impact processing technology selection include:

- Distribution of hydrocarbon components in the feed stream (composition)
- Forecasted production profile of the hydrocarbon reserve
- Feed contaminants including acid gas (CO2, H2S, mercaptans), mercury, arsenic, and nitrogen
- Feed pressure and ambient conditions – at the well and along the pipeline to the processing facility
- Onshore vs. offshore situation of resources and processing equipment
- Regional fiscal regime impacting project funding
- Environmental constraints, either local or global

Ignoring one or more of these factors will have a detrimental impact on the operability of processing facilities and the overall success of projects. For example, not accounting for low levels of contaminants that are in the feed (e.g. mercaptans) or making do with estimates that turn out to be wrong may lead to sub-optimal solutions that are implemented at the last minute to avoid producing off-spec products.

When considering plant configurations and design decisions, operating flexibility should serve as a key design objective for the processing system. Flexibility is important due to the complex interrelationship and relative uncertainties among (i) upstream input factors, (ii) interactions among upstream and midstream processing functional blocks, and (iii) overall delivered product economics and/or other downstream commitments.

Issues and Challenges

Following are examples of issues and challenges that we have seen in managing the full range of hydrocarbons:

- Gas streams are re-injected without recovering hydrocarbons because the infrastructure is not in place or because the available technology is awkward;
- Gas is flared during early production of oil wells;
- Development of fields is reduced or delayed because contaminants are difficult to remove;
- Products with potentially higher value are left in pipeline gas – sold only for its fuel value;
- Ad hoc process control solutions leading to underutilized data and sub-optimal operations;
- Quick early processing facilities that need to be upgraded and optimized for long term efficiency;
- Changing markets – the relative value of different products no longer matches the original investment decision;
- Stranded resources may require conversion to product forms that are easier to transport;

These challenges and others like them can be addressed by a solid focus on hydrocarbon management that draws solutions from a deep portfolio of processing technologies with access to a broad range of know-how; keeping the whole system in view.

Hydrocarbon Management Creates Value

Hydrocarbon management creates value by addressing challenges with flexible, system based technologies; converting losses and undervalued uses to incremental revenue.

- Improving the efficiency of operations with good maintenance programs (preventing leaks) and good control systems (preventing upsets and flaring events) has a direct impact on reducing costs and increasing revenue.
- Improving the efficiency of fuel consuming equipment or changing the fuel type can directly create value by limiting the amount of higher value products that are consumed for energy production. This can also create value by reducing emissions related costs.
- Separating higher value products from mixed streams adds additional revenue sources. In most global markets, it pays to extract Natural Gas Liquids (NGLs) from natural gas beyond simple gas dew-pointing. Initial project costs are greater but the resulting NPV makes these projects attractive. Using a technology that can vary the amount of ethane that is recovered depending on industry conditions keeps the whole system in view.
- By understanding processing technologies in the context of the overall marketplace, hydrocarbon management can create significant value by leading producers to staged investment solutions using flexible modular processing facilities.

Examples

CO2 Enhanced Oil Recovery

CO_2 Enhanced oil recovery (EOR) involves flooding oil reservoirs with injected CO_2. Depending on well pressure the CO_2 mixes with or displaces oil improving the flow and extending the productive life of the well. Generally, between about 40% up to about 70% of the injected CO_2 returns to the surface with the oil. After separation, the associated gas will contain from about 30% to as much as 90% CO_2 depending on many factors.

Objectives:

Recover natural gas liquids (NGLs) and pipeline quality natural gas from the high CO_2 associated gas stream before returning the CO_2 rich stream for reinjection.

Challenges:

The volume and composition of the CO_2 rich gas can change significantly over the life of a project as CO_2 breakthrough increases.

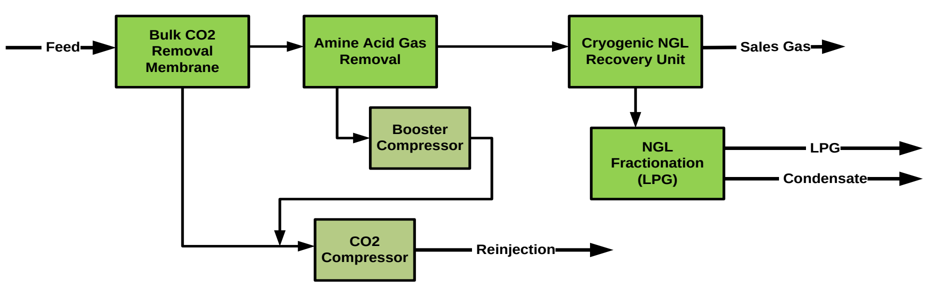
Deep recovery of NGLs, which is desirable, requires a cryogenic process. But cryogenic processes are susceptible to CO_2 freeze.

CO_2 compression for reinjection requires a large amount of power.

Hydrocarbon Management Solutions:

Bulk CO_2 is removed with membranes while a solvent (amine) based system can be used to further treat the gas to pipeline specifications.

Flexible cryogenic turbo-expander based NGL recovery plant can be used allowing for recovery or rejection of ethane depending on industry conditions. Additional NGL fractionation can be added – either during the initial project or as an added investment later.



Looking at the whole system, it may be possible to use a more CO_2 tolerant cryogenic unit and eliminate the need for an amine unit for full CO_2 removal. For example, if the gas will be used for power generation it is often possible to accept 10% or even higher CO_2 concentration in the fuel gas.

Benefits:

Membrane systems can easily handle changing feed conditions and are easy to expand to accommodate the increasing CO_2 from EOR operations. This allows the operator to maintain a relatively constant feed to the NGL recovery unit. The incremental investment in expanding the membrane system is small compared to expanding alternate technologies. The membrane system can also be configured to deliver CO_2 rich permeate to the CO_2 compressors at an elevated suction pressure reducing power consumption.

Small Scale LNG for Flare Reduction

When a cluster of wells are brought online in a new development area, associated gas is flared while oil is produced. One development produces about 16 MMSCFD of associated gas which can be considered as lost hydrocarbons.

Objectives:

Make use of the associated gas rather than losing it to the flare.

Challenges:

The location of the new development is fairly remote relative to existing gas pipeline infrastructure. And the gas flow is relatively small so that it is not economical to install a dedicated pipeline to take the gas to market. However, the lost gas still represents as much as $34M per year in lost revenue opportunity.

Hydrocarbon Management Solutions:

A small scale packaged LNG plant is installed to capture the revenue from the lost hydrocarbons. The liquefied natural gas can be transported by truck to customers. This also recovers additional stabilized condensate which is added to the produced oil, increasing those revenues.

Benefits:

A study of the economics for this application shows that the return on investment depends on the cost of electrical power.

200,000 gal per day plant	Project Scenarios			High
	Low	Mid	High	Elec
Electric Power ($/kWhr)	**$0.05**	**$0.055**	**$0.06**	**$0.08**
Pipeline Gas ($/MSCF)	**$2.50**	**$3.75**	**$5.00**	**$5.00**
CAPEX/gal of LNG (¢/gal)	**7.85**	**7.85**	**7.85**	**7.85**
DGE	13.15	13.15	13.15	13.15
OPEX/gal of LNG (¢/gal)	**7.68**	**8.29**	**8.91**	**10.66**
DGE	12.86	13.89	14.92	17.86
COGS ¢/gal of LNG (*Excl NG Feed*)	**15.53**	**16.15**	**16.76**	**18.52**
DGE	26.01	27.05	28.07	31.02
IRR (EBITDA)	**26%**	**20%**	**13%**	**12%**

Assumptions & Conversions:

Operating rate = 80% of plant capacity; 15 yr plant life; LNG sales price = $0.95.; discount rate=10%

Staged Expansion to Match Field Development

When new fields are developed, production forecasts show a large difference between early phase production volumes and the ultimate maximum flow expected from the wells. In one particular example, production forecasts expect to require up to 1200 MMSCFD of gas processing capacity but will only have about 200 MMSCFD available at the beginning of production.

Objectives:

Realize revenue from the produced gas as soon as possible while planning for the maximum production and at the same time maximizing the ability to make the best mix of products over the life of the facility.

Challenges:

The actual production can be very different from the early forecasts; both in flow rate and in fluid characteristics. The investment needed to install the full facilities for the total expected capacity is very large and is best financed by cash flow from early revenues using a phased approach.

Site work for such a large plant can be very disruptive and can encounter delays with a conventional approach that might consist of building two large processing trains of 600 MMSCFD each. Such an approach would also introduce additional downside risks based on the possibility that the forecasts are high.

Hydrocarbon Management Solutions:

A modular gas processing plant is used that consists of up to six trains with 200 MMSCFD capacity each. Each train is initially designed to be identical but because of the modular design, adjustments can be made to individual trains in response to changing forecasts without compromising the entire project. For example if the produced gas becomes richer over time, additional refrigeration modules can be added without affecting the design of the core units.

Benefits:

The initial investment is much more manageable and production can begin much earlier. Cash flow from the first phase can provide capital for the follow-up phases. Flexibility is maintained to respond to actual production rates and conditions.

Since each train can turn down independently, and since each train can be augmented with additional process modules when required, operating flexibility for the entire system is enhanced.

Conclusion

In each of these examples it can be seen that an approach that takes a systems view, takes an early look at all the tradeoffs and focuses on flexibility and adaptability can make the difference in producing projects that manage hydrocarbons for improved profitability, better yields and reduced environmental impacts.

UOP, a Honeywell company, has the technologies and tools available to help its customers with hydrocarbon management. These tools include a broad portfolio of process technologies delivered both as licensed processes and modular packaged process plants. These technologies remove contaminants, treat, convert and separate hydrocarbons in well integrated systems that also include auxiliary systems such as flares and thermal oxidizers, advanced process controls, safety systems and more.