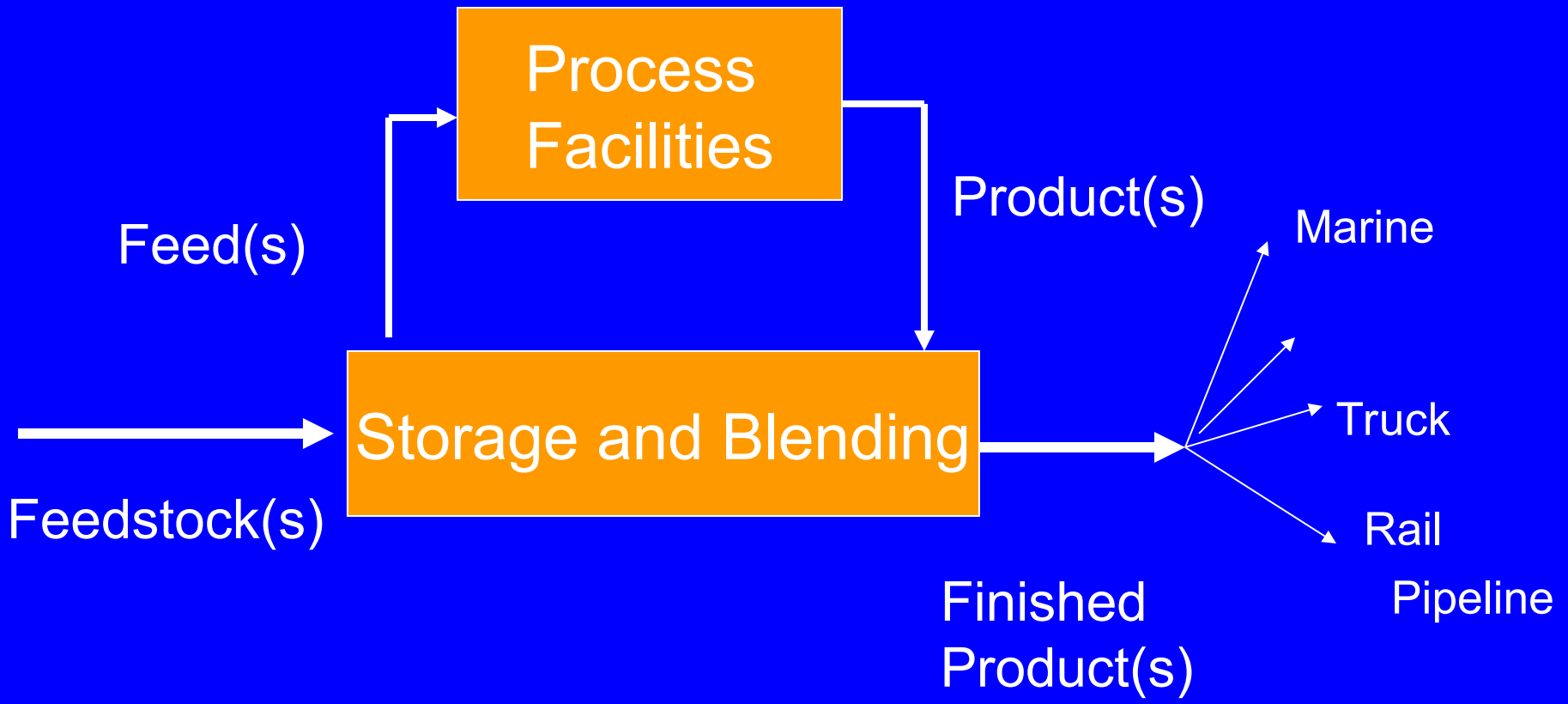
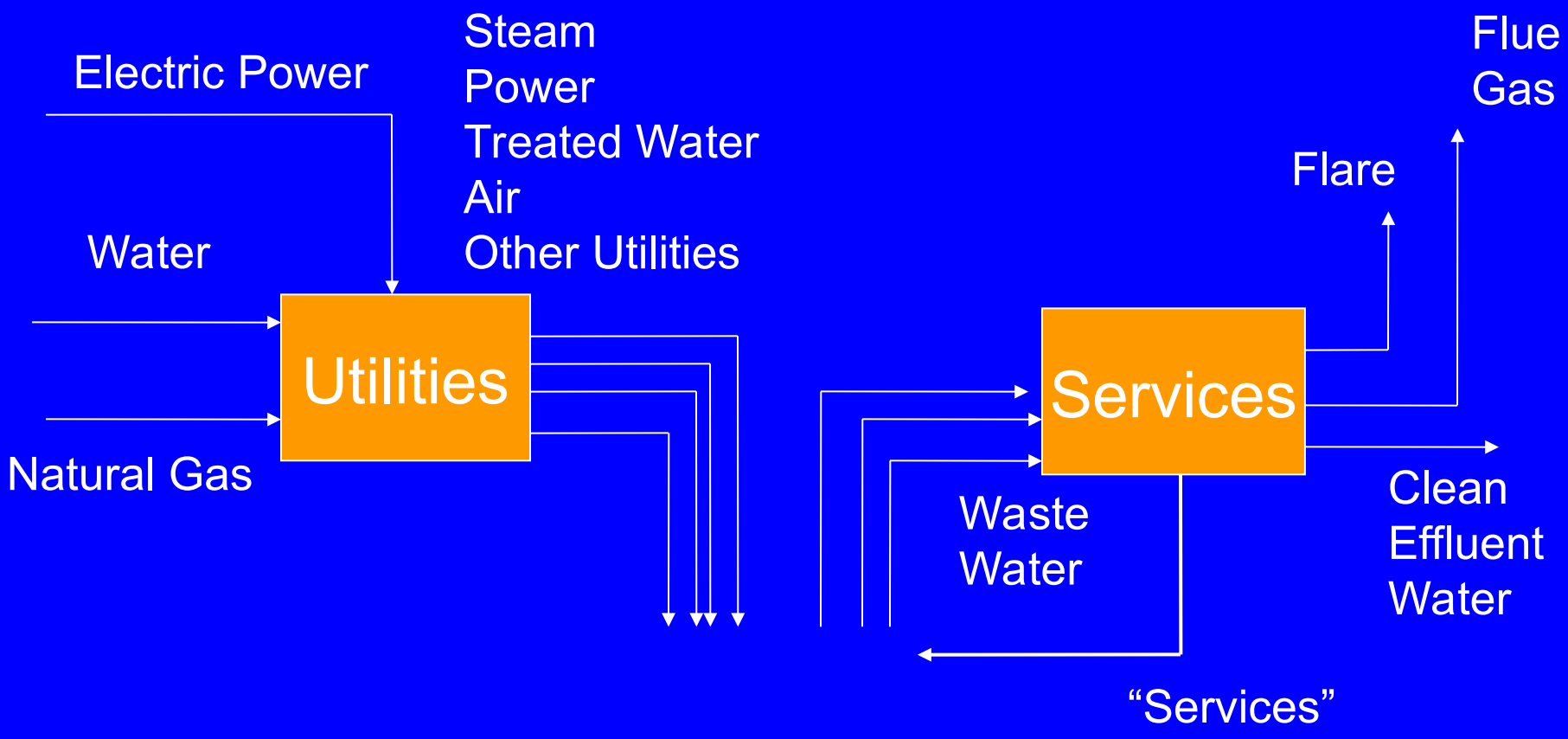
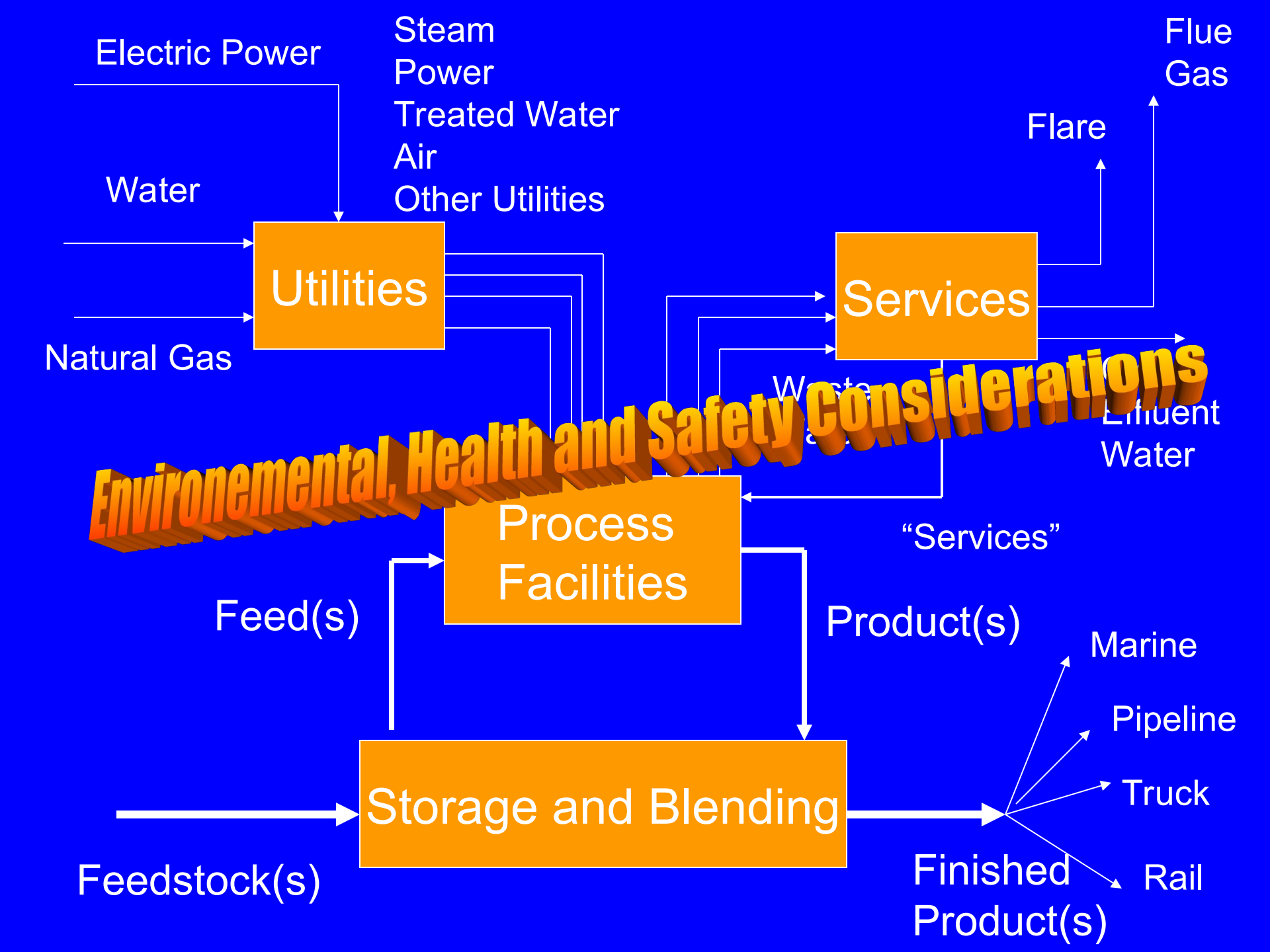

Feedstock(s)
Process Plant
Product(s)


Process Facilities
Feed(s)
Product(s)
Marine
Truck
Rail
Pipeline
Storage and Blending
Feedstock(s)
Finished Product(s)


Electric Power
Steam
Power
Treated Water
Air
Other Utilities
Water
Utilities
Natural Gas
Flue
Gas
Flare
Services
Clean
Effluent
Water
Waste
Water
“Services”


Electric Power
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Water
Utilities
Services
Natural Gas
Waste
Effluent
Water
Environemental, Health and Safety Considerations
Process
Facilities
"Services"
Feed(s)
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Storage and Blending
Feedstock(s)
Finished
Product(s)

Process Design is
A Systems Engineering Process

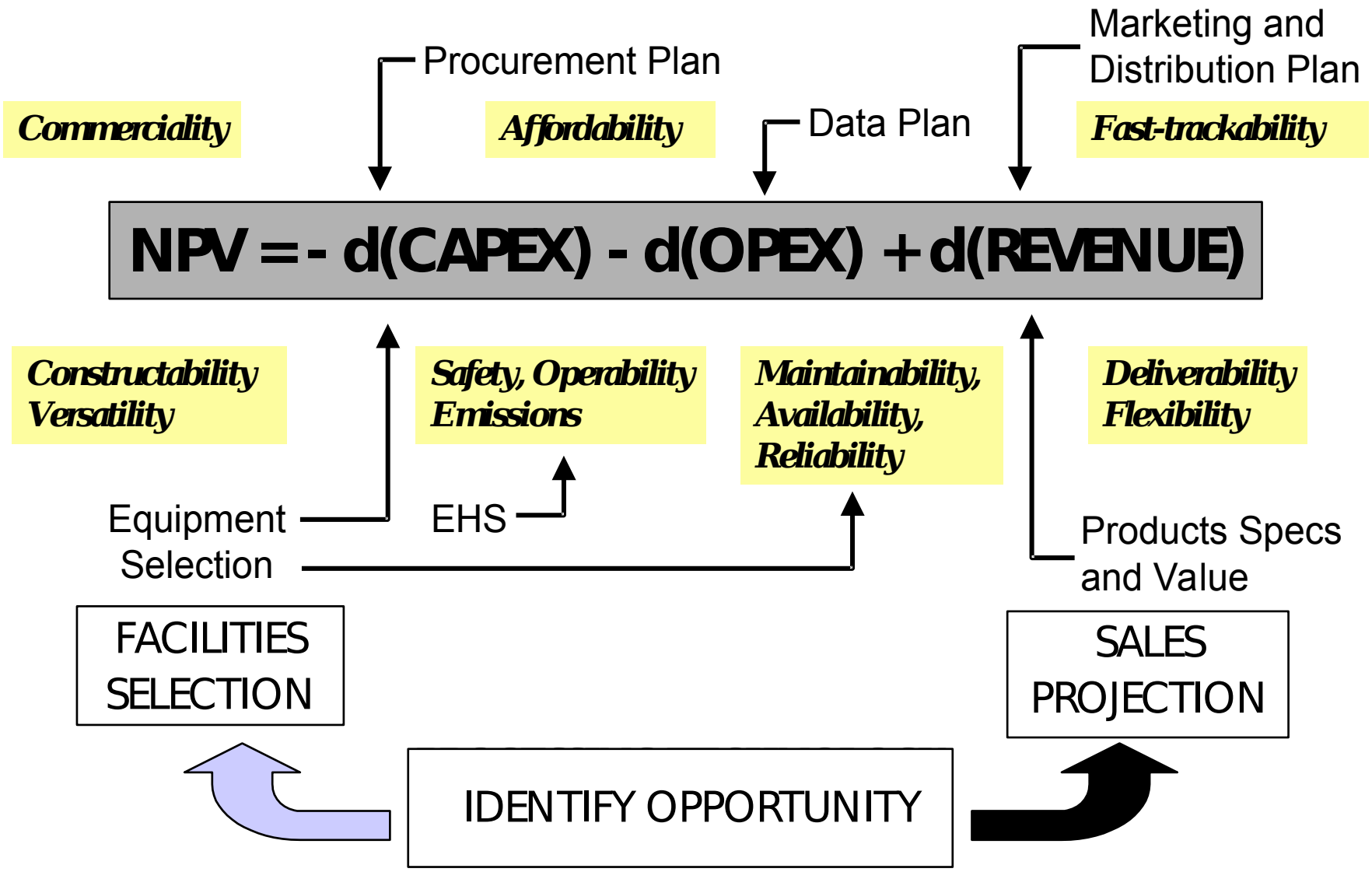
What is a Systems Engineering Process?

- View the business objective as a single entity
- Consider raw materials sources, inbound logistics, manufacturing, sales, and distribution strategies necessary to get to the desired result
- Consider all phases: feasibility, engineering, construction, operation and termination
- Includes All Stakeholders wants and needs
- Plans to address key requirements (‘ilities)
- Identify prime elements within each requirement
- Define how to specify and analyse performance targets
- Eliminate repetition and duplication

Key Requirements (the 'ilities')

- Commerciality
- Affordability
- Constructability
- Processing flexibility
- Operability
- Controlability
- Reliability
- Maintainability
- Availability
- Deliverability
- Versatility
- Expandability

SYSTEMS ENGINEERING INTERFACES



To be a “Money Maker” your Process must...

- Maximize conversion of high valued feedstocks to the desired product(s).
- Be energy efficient.
- Have a low capital burden per unit of production.
- Have low overall operating costs.

All Process Designs are a Series of Building Blocks

- Feed preparation
- Adjustment to reaction conditions
- Reaction
- Quench
- Gross Separation
- Separation of co-products from Product
- Product purification
- Co-product purification
- Destruction of undesired byproducts

Feedstock Preparation is Usually Required

- Pretreatment is required to remove undesired molecular species which may either,
  - inhibit the reaction, or
  - result in unwanted products or co-products.
- Picking the wrong feed preparation scheme puts the whole process at risk. Be conservative.

Adjustment of Reaction Conditions for Best Effect

- Very few reactions occur most favorably at ambient pressure and temperature
- Temperature increases should first be done by exchanging heat with the reaction products or other hot streams
- Most reactions where gas is the reactant or a product will require adjusting reaction pressure for best yield. This will require a compression step

Conversion Per Pass Vs. Total

- Low conversion per pass means that you will have increased investment and operating expense for separation of products from reactants and subsequent recycle to the reactor

- The separation scheme selected can make or break the economics on both capital cost and energy costs.

Reaction and Quench

- Typically there is a catalyst involved and sometimes a “promoter” is also involved
- Rapid disengagement of the reactants from the catalyst may be required
- Quench may be required if heat of reaction is excessive and temperature rise too great
- Competing reactions will require rapid termination of the reaction to minimize the production of Co-Products and By-Products

Reactor Design Depends on:

- the contact time required,
- whether the reaction is exothermic or endothermic,
- whether the system is homogeneous or mixed phase, and
- whether rapid disengagement and/or quench is required.

Gross Separation

- Once the reaction mass is disengaged from the catalyst, the next step is typically gross separation of the un-reacted feedstock from the reaction products.
- The un-reacted feedstock is typically recycled back to the reaction system.

Separation of Co-Products from Product

- The most common separation method is by distillation
- Crystallization, filtration, decanting, elution, mole sieves, membranes, or other separation process can also be used if appropriate

Product Purification

- Product purification is most commonly achieved by further distillation
- Crystallization, extraction or some other process may also be used depending on the physical and VLE properties of the system.

Co-Product Purification

- Where Co-Products have value, they too should be purified as with the primary Product.
- If the Co-Products or By-Products are not high enough in volume or value to merit recovery and purification, then they must be…
  - directly recycled,
  - disassociated back to primary reactants, or
  - incinerated to recover their energy content.

Summary

- Consider the impact of each process building block on all other building blocks.
- Maximize conversion per pass.
- Maximize the value of Co-Products and byproducts.
- Maximize energy transfer between process streams for best thermodynamic efficiency.
- Start thinking now about the most important control variables.