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GASIFICATION TECHNOLOGIES CONFERENCE 2008

Optimizing Capex and Reliability on Gasification Facilities

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Jacobs Consultancy

Agenda

- Who we are
- Gasification business drivers
- Delivering drivers through RAM analysis
- Case studies

Jacobs Consultancy

- Originally Pace Consultants Inc., established 1957
- 1974 – acquired by Jacobs Engineering
  - 55,000 employees, Annual revenue ~$10 billion
- ~150 professional staff in USA, Canada, UK, Netherlands
- Worldwide experience
  - Refining & Production
  - Chemicals & Petrochemicals
  - Natural Gas
  - Energy & Utilities
  - Environmental Services
  - Transportation & Infrastructure

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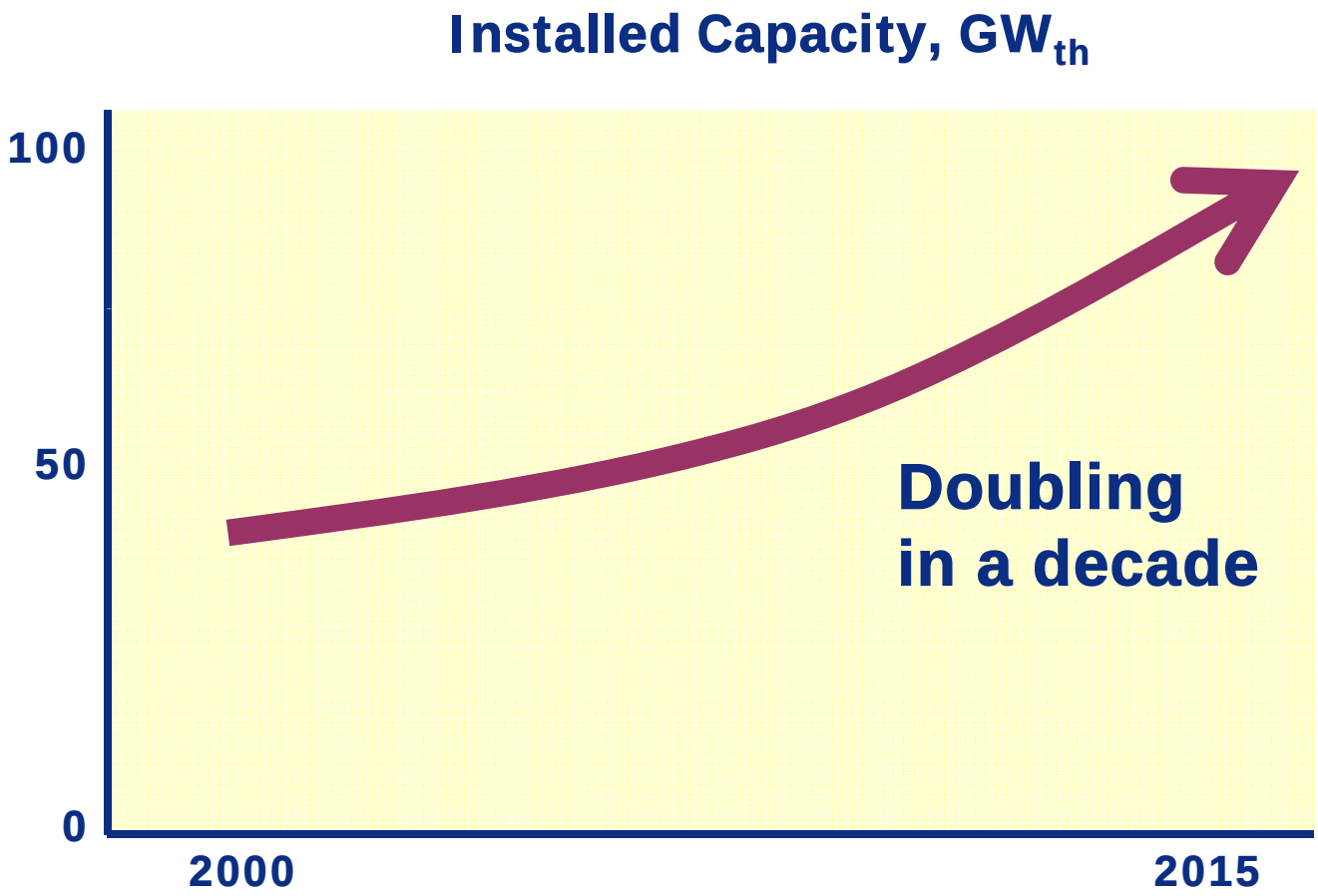
The Growth of Gasification



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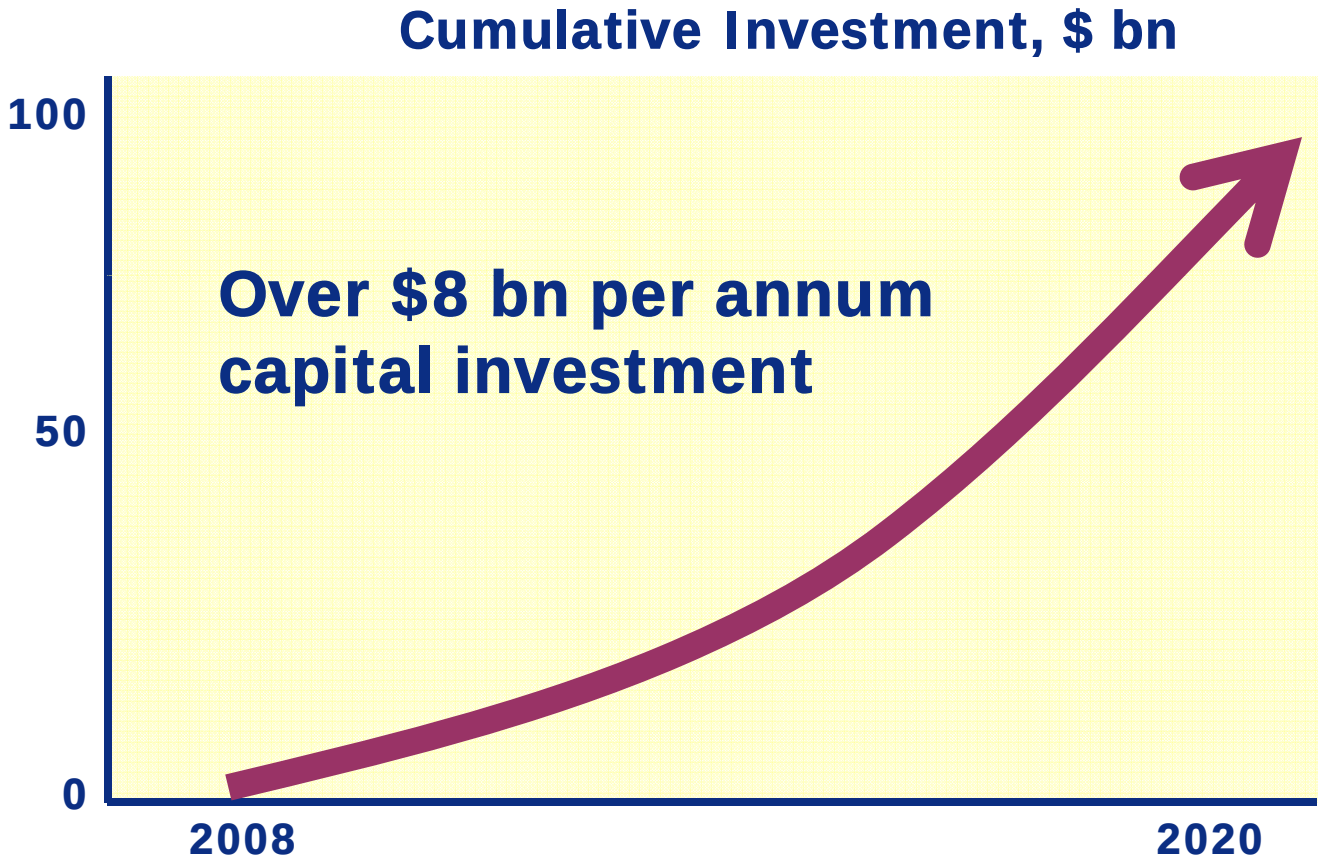
Future Capital Investment in Gasification



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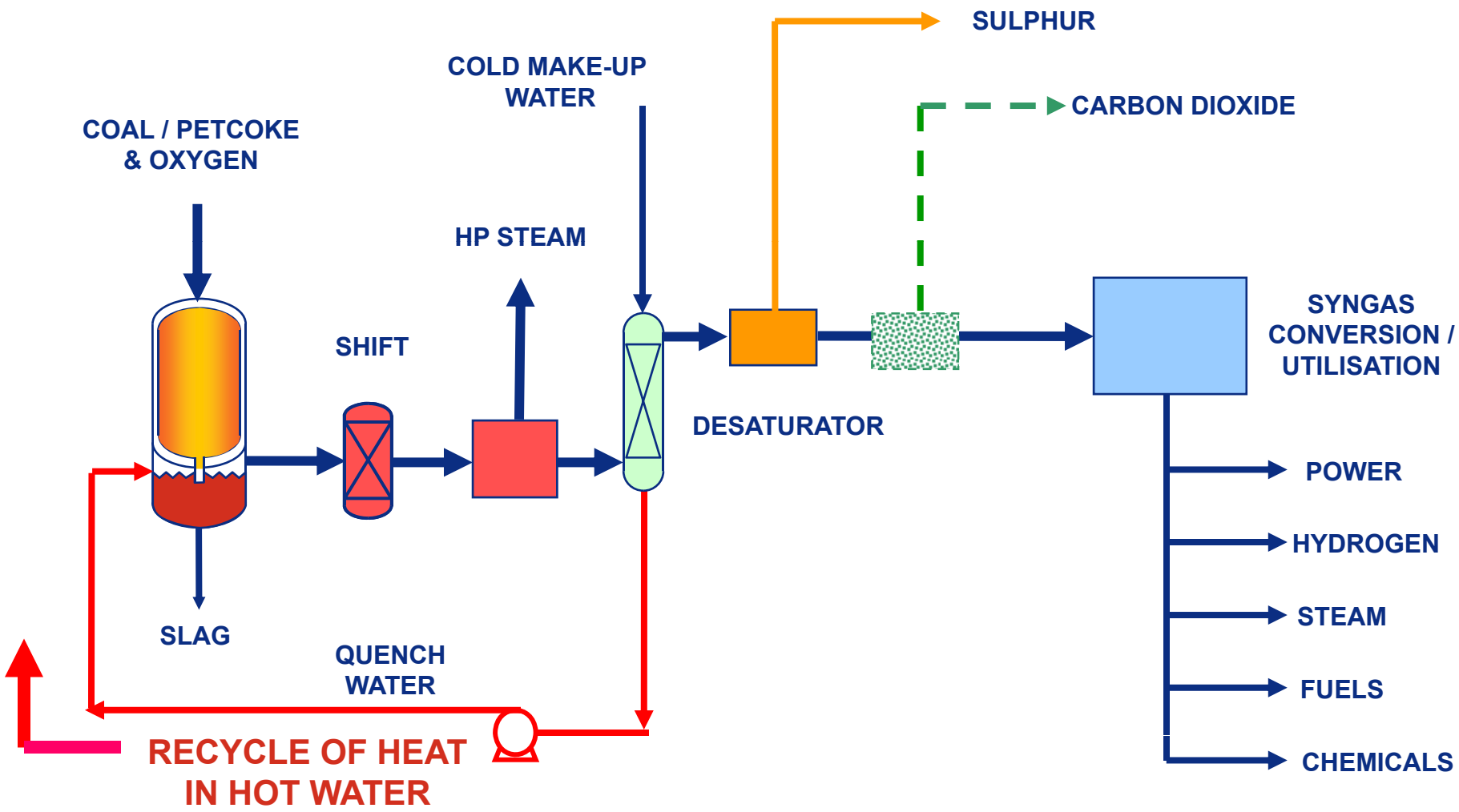
Gasification – The Future Looks Bright

- IGCC
  - "Clean coal" power generation
  - Carbon capture ready / capture now
- Refinery & Upgrader Applications
  - Consume petcoke / residue
  - Produce hydrogen, steam, power - polygeneration
- Coal to Liquids / Coal to Chemicals
- Biomass / Waste / Opportunity Fuels

Gasification Product Flexibility



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So What is Holding Things Back?

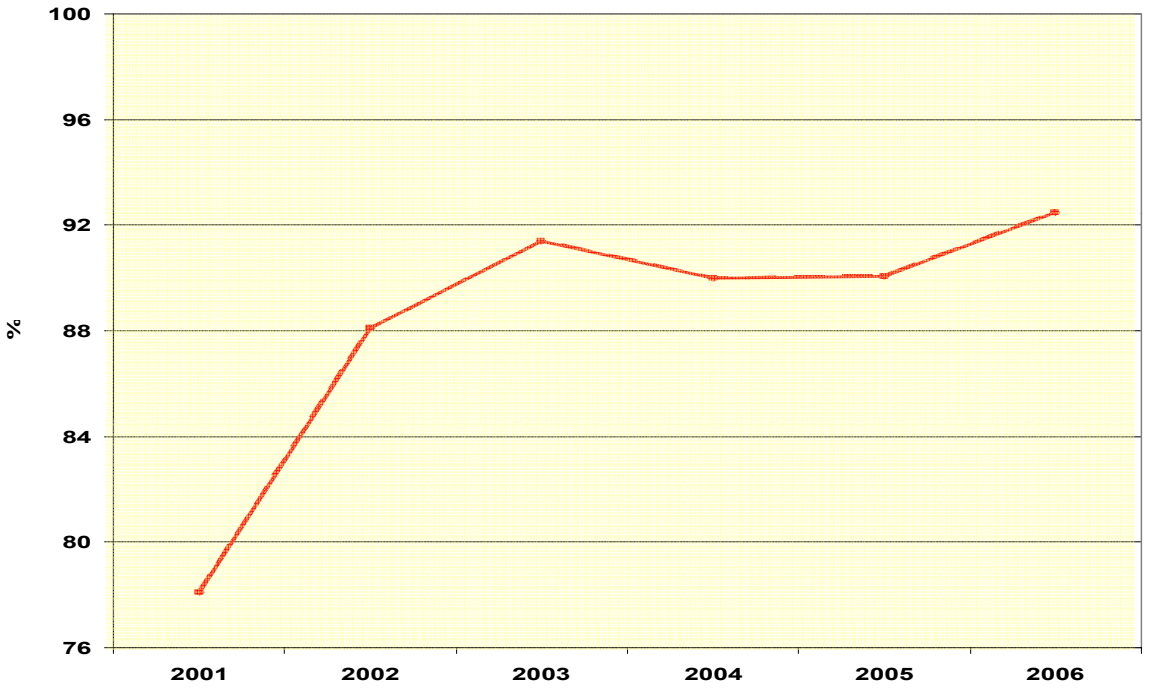
- **Not** the technology
  - All unit operations are commercially proven
  - Low technology risk - “bankable” technology
- Money
  - High capital costs – presents a challenge to obtain finance
  - Project economics – can threshold IRR be obtained?
- Uncertainty over CO_2 emissions
  - Emissions limits / trading systems / carbon tax?
  - Requirement to capture / offset emissions?
  - Is it worth pre-investing in carbon capture?

So What is Holding Things Back? (cont.)

- Availability / Reliability
  - Not the greatest track record – but improving
    - Reputation has suffered
  - Highly complex process - outside the comfort zone of many operators (especially power producers)
  - Need to match the availability / reliability performance of existing and competing technologies

Example - Operating IGCC

- Typical IGCC facility
- Initial teething issues
  - Equipment
  - Human
- Focused efforts
  - Reliability Improvements
  - Operations Optimisation
  - Availability increased
- Lacked early attention to reliability during design



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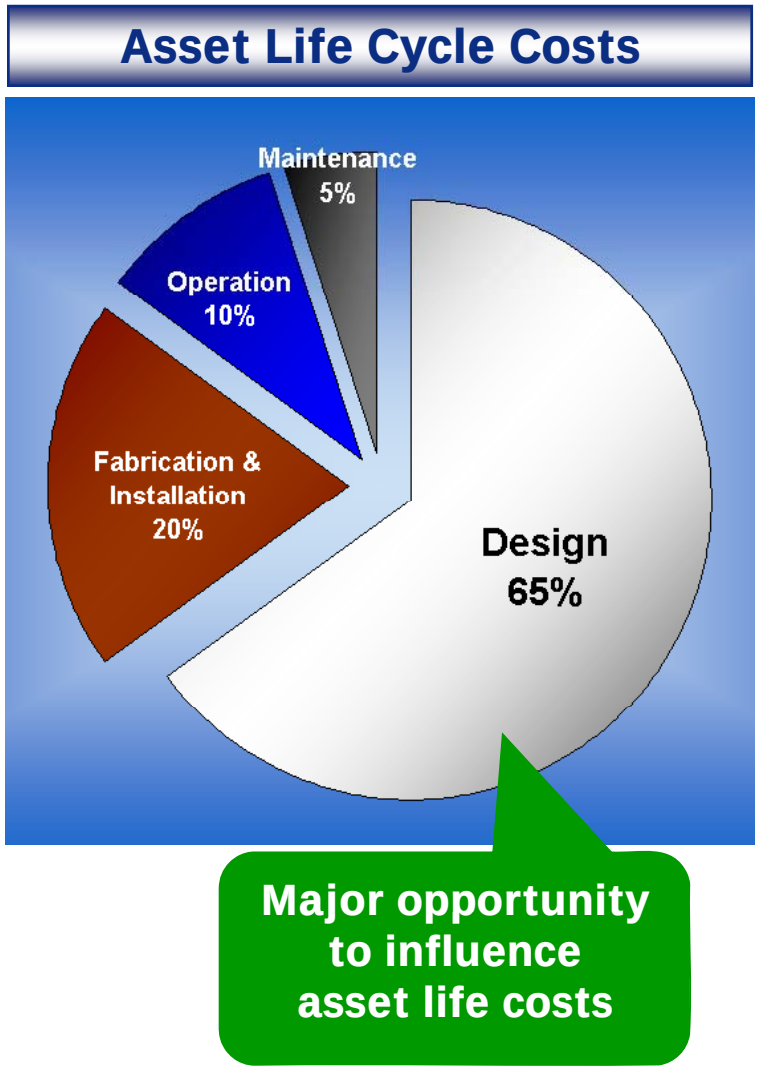
Availability Concerns – Refinery Hydrogen

- Refinery requires hydrogen at >98-99% availability
- Gasification plant product availability <90%
- What to do?
  - Add spare gasifier(s) & other key equipment
  - Add steam methane reformer as back-up
  - Prioritise hydrogen production from a polygeneration facility
- But need to be able to quantify the achievable availability from any possible configuration

Business Drivers

- Minimise CAPEX
- Increase uptime
- Optimise maintenance costs
- Maximise economic life
- Optimize life cycle costs

Why RAM - Influencing Asset Costs



Design	Selection of the minimum lifetime, dimensions, material, safety coefficients, corrosion allowances, leak-before-break, observance of findings in HAZOP, RBI, RAM…
Fabrication & Installation	Qualification of the fabricator and installer (selection procedure), quality assurance & control, experience of the supervisor of fabrication…
Operation	Qualification (training) and motivation of the operation personnel, compliance to procedures, observance of operating envelopes and practices…
Maintenance	Qualification (training) and motivation of the maintenance personnel, compliance to procedures for service, inspection, condition monitoring, spare parts strategies…

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Some Key Definitions

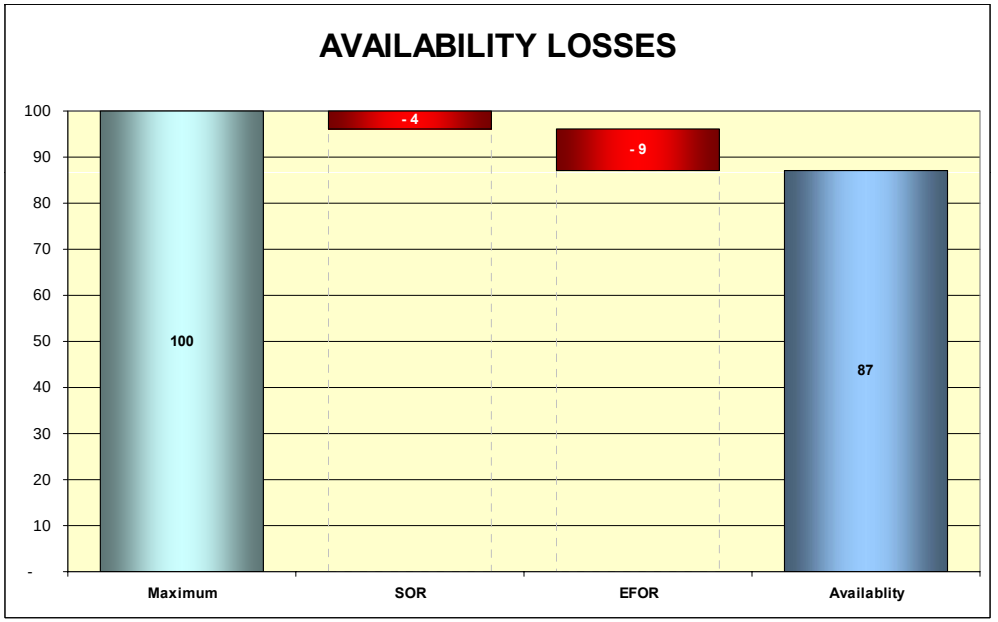
- **RAM (Reliability, Availability & Maintainability)**

- **SOR (Scheduled Outage Rate)**
  Fraction of specified period, for which the system is not available due to scheduled maintenance.

- **EFOR (Equivalent Forced Outage Rate)**
  Fraction of specified period, for which the system is not capable of performing a specified level of performance due to unplanned outages, in which outages are weighted for the percentage of capacity not being available.

- **A (Availability)**
  Probability that a system is able to perform up to a defined standard:

  A = 1 – (SOR + EFOR)



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Address EFOR Early

- Utilise RAM Modelling at design
- Structured approach to represent the “system” and reflect how it will perform
- Statistical representation of key items
- Requires input parameters:
  - Reliability - failures
  - Maintenance - repair
- Utilise Quantitative Risk Assessment

Why RAM Study?

- Assess Reliability / Availability performance
  - Throughput analysis
  - Weak points
  - Identify bottlenecks
- Configuration of process units / streams
- Configuration of critical equipment
- Optimizing planned maintenance strategy
- Optimizing sparing philosophy

Use selectively to maximise return from effort

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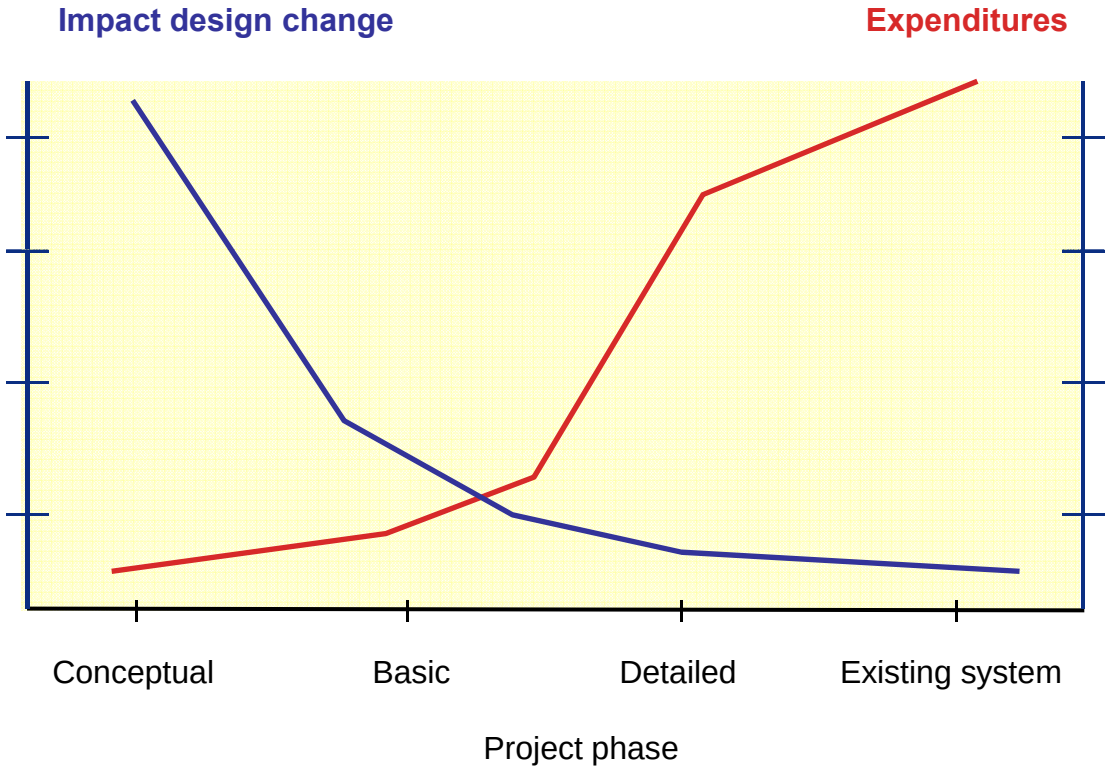
When RAM Study?

- Applicable at all stages:
- Feasibility
  - Concepts and configuration options
  - Input into financial model
- Design
  - Equipment selection
  - Sparing strategies
  - Maintenance strategies
- Operation
  - Bottlenecks / Gaps
  - Enhancements



Start early = Maximum benefit

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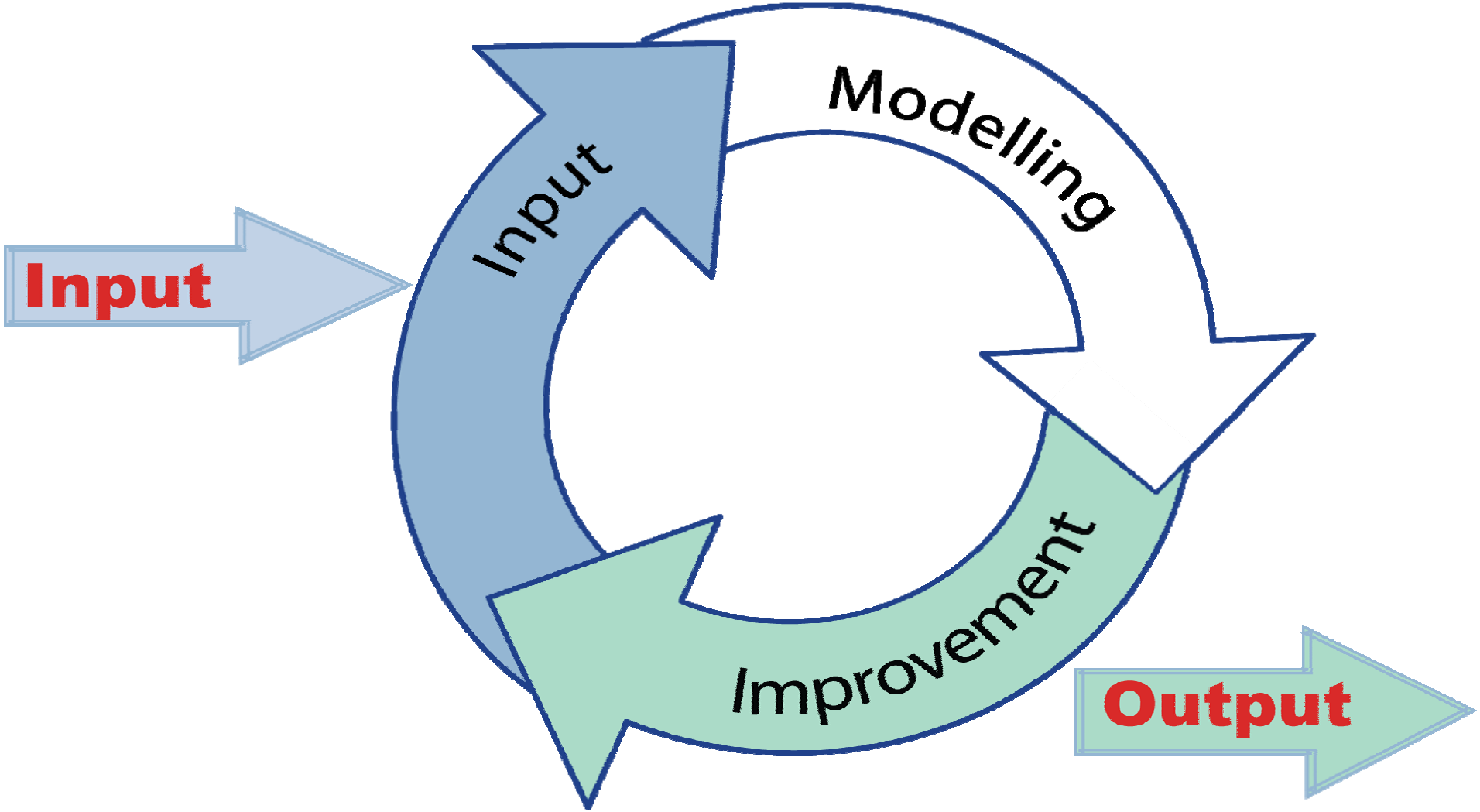
The RAM Modelling Process



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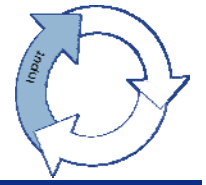
Data Needs



- Basic information
  - Reliability - Failure data (MTBF, failure rate)
  - Maintenance - Repair data (Repair time, effort)
- Generic data ⇨ OEM data ⇨ Operator data
- Refine throughout design phases

System	Description item	MTBF * Mean Time Between Failure [hrs]	MTTR * Mean Time To Repair [hrs]
Gasifier	Recycle compressor	140,000	176
Shift	HP BFW heater	43,800	40

*** for example**

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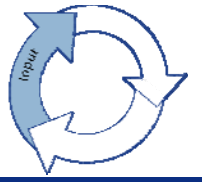
Optimum Approach



- Combine RAM expertise with project team
- Utilize knowledge from:
  - Project team
  - Licensors
  - OEMs
  - O&M (existing)

RAM	**Technical**
Process	**Operations**

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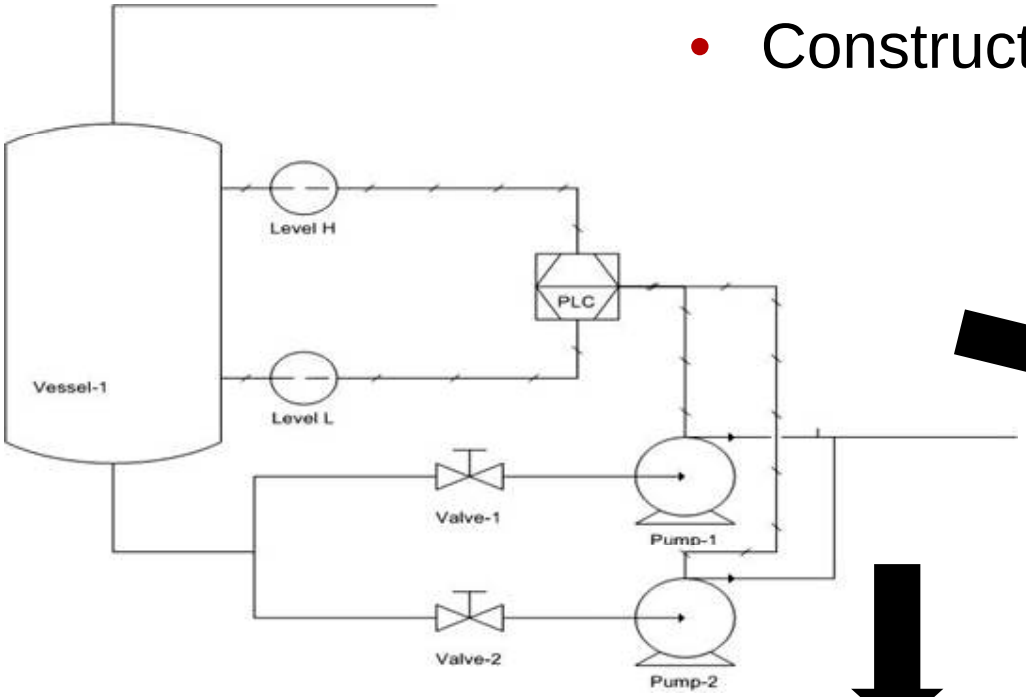
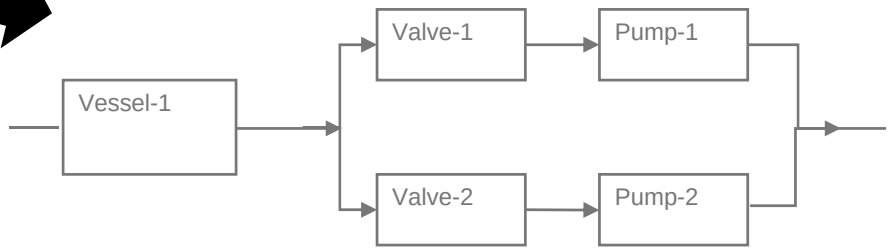
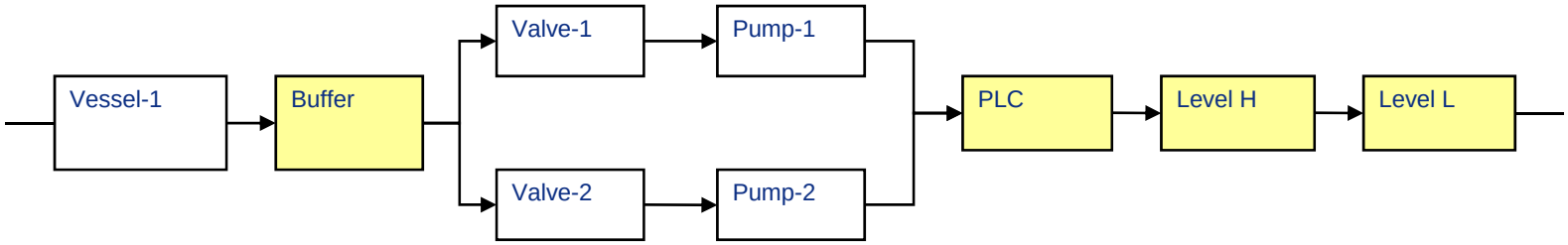
Reliability Block Diagram (RBD)

- Construct RBD using PFD and P&ID





Block Flow Diagram



Reliability Block Diagram

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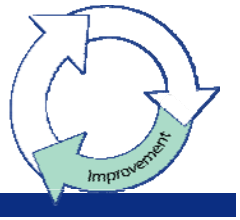
Improve System Availability



- Key approaches…
  - Installed spare
  - Installed bypass
  - Increase maintenance frequency
  - Warehouse spare
  - Different equipment type

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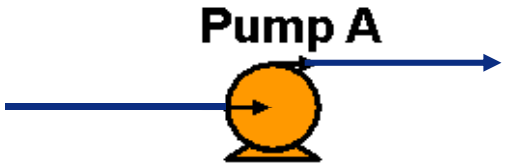
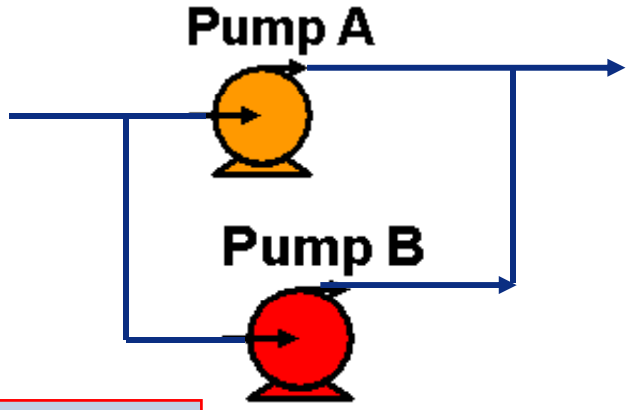
Improvement - Installed Spare

- Install spare equipment
- Need associated services
- CAPEX increase
- Plot increase
- Life cycle costs increase



90%

Pump A or Pump B is active



99%

Reduce downtime → Increase availability

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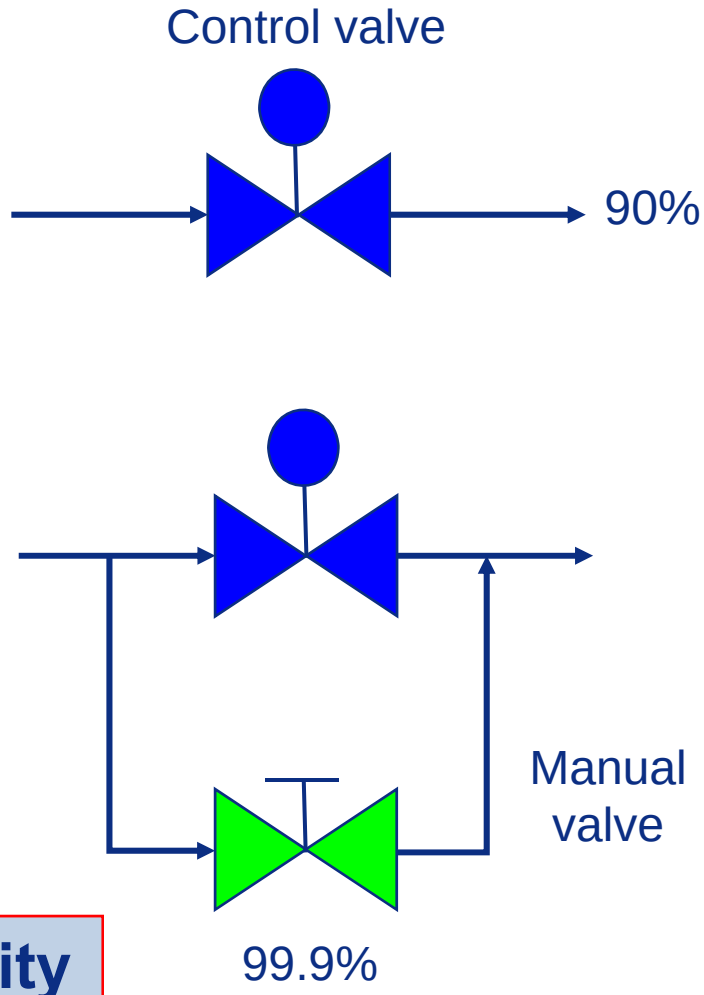
Improvement - Installed By-pass

- Enable equipment to be repaired online
- Only possible for a short periods
- Operating procedures required
- Lower CAPEX than installed spare



Reduce downtime → Increase availability

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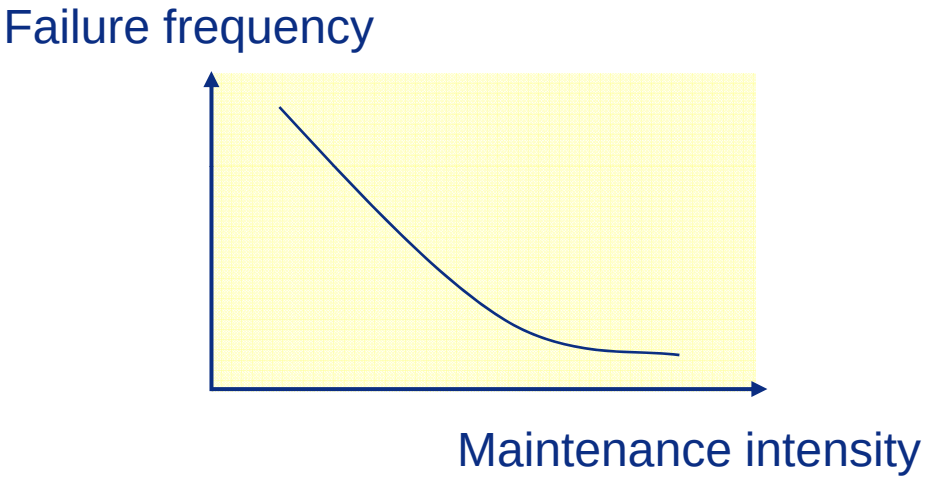
Improvement - Increase Maintenance

- Increase maintenance efforts
- More proactive maintenance strategies
- Equipment failures will reduce
- Operational expenditure increase



Reduce failure frequency → Increase availability

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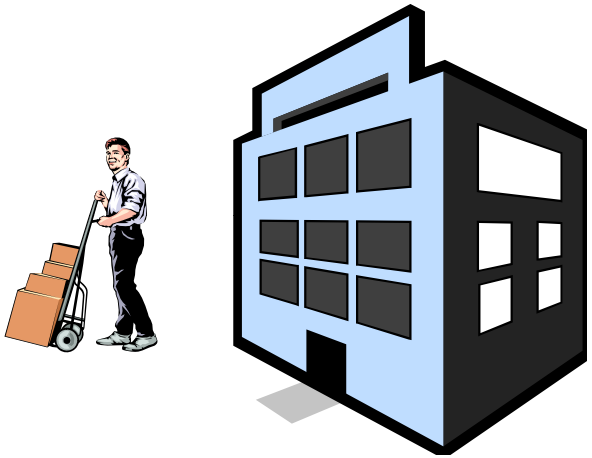
Improvement - Warehouse Spare

- Reduce the time to get a spare to site
- Hold complete items
- Working capital
- Relationship with vendors



Reduce downtime → Increase availability

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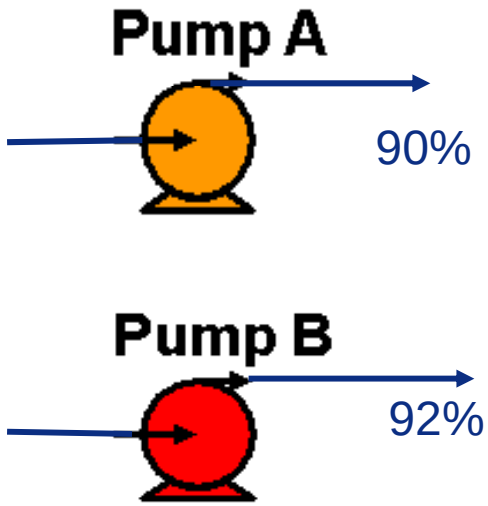
Improvement - Different Equipment Type

- Function A = Function B
- Failure frequency A > Failure frequency B
- Requires
  - More spares
  - O&M skills and training



Reduce failure frequency → Increase availability

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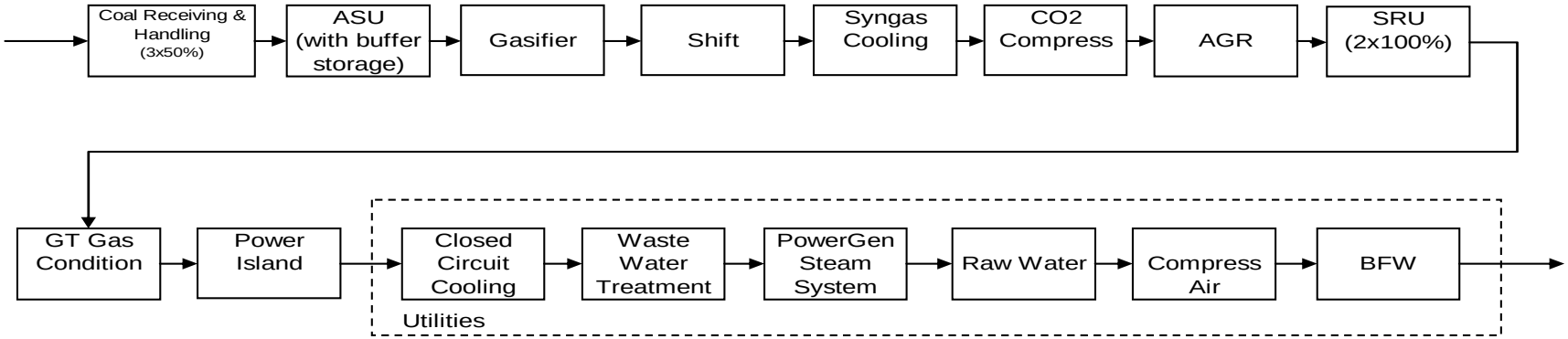
Example – IGCC Project, UK

- RAM scope:
  - Provide indication of the system availability for the proposed facility design
  - Develop preliminary reliability model that can be further enhanced and used for relative comparison decision-making during the future phases of the Project
- Benefits:
  - Determined base-case availability of individual process units & entire facility
    - Overall availability of base design below target figure
  - Identified process modifications to increase availability by >3% to meet target
    - Add spare train in SRU
    - Add spare coal receiving & handling system
    - Add LOX / LIN storage and vaporisation to ASU



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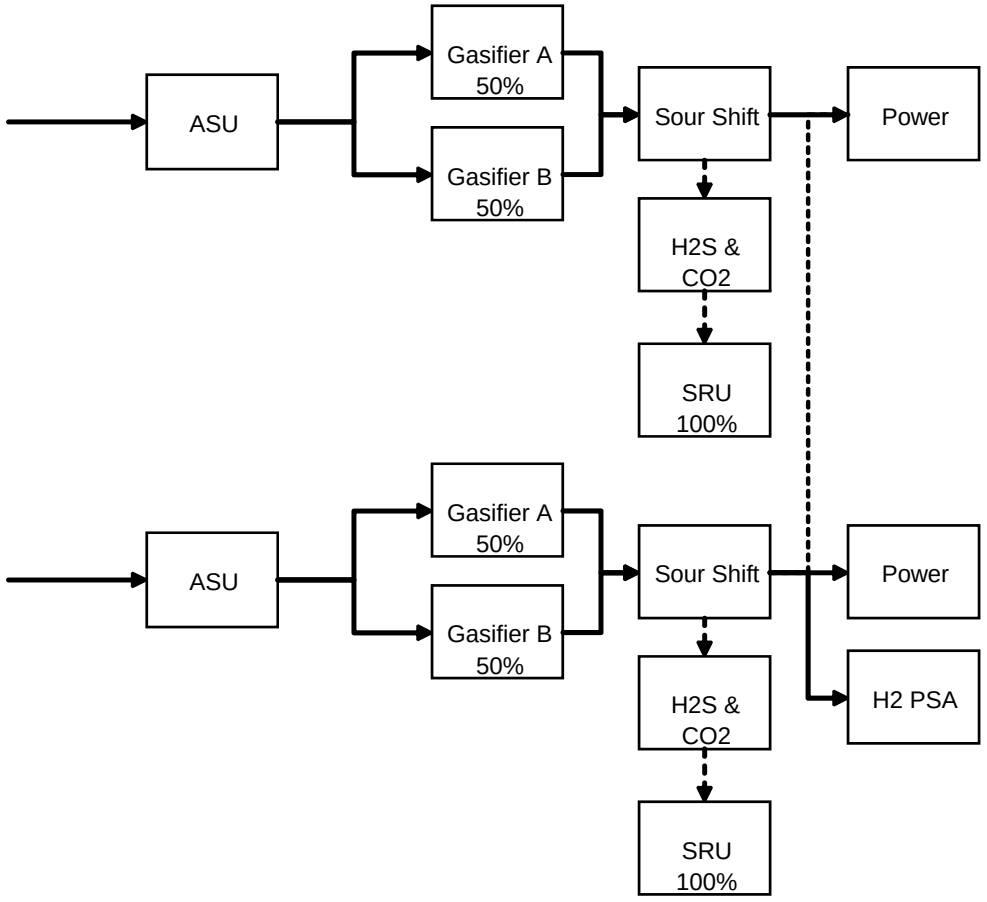
Example – Asphaltene Gasification Project, Canada

- Base-case availabilities determined for separate power train and H_2 train
- Hydrogen availability increased by >11% by addition of single interconnection between trains
  - Hydrogen prioritised over power
  - Addition of spare equipment avoided



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Example - Value of Availability & Reliability

Performance Indicator (700 MWe)	Value of Availability & Reliability *(assuming a 1% influence)*				
	%	Additional MWh/yr	Rate US$/MWh	Additional $million/yr	NPV* $million
EFOR	1.0%	61,320	100	6.1	38.4
SOR	1.0%	61,320	20	1.2	7.7
Availability	*2.0%*	*122,640*		*7.3*	***46.1***

*Indicative, at 15% discount rate

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Benefits from RAM Modeling

- Supports development of the Asset Management Strategy
- Enables the optimization of…
  - Configuration
  - Maintenance strategy
  - Sparing philosophy
  - Critical equipment / systems
- Feeds directly into the Financial Model

Summary

- Gasification processes = technology and CAPEX intensive
- RAM modelling essential to enable informed decisions effecting asset life
- Start activity early and develop accuracy
  - Design of new process facilities
  - Revamp / improvements
  - Conceptual phase
- Use to develop configurations
  - Optimize capital expenditure by increasing facilities' reliability
  - Optimise maintenance spend
- Essential component of comprehensive Asset Management strategy

For More Information…

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