CCS Chain Integration

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What is CCS Chain Integration?

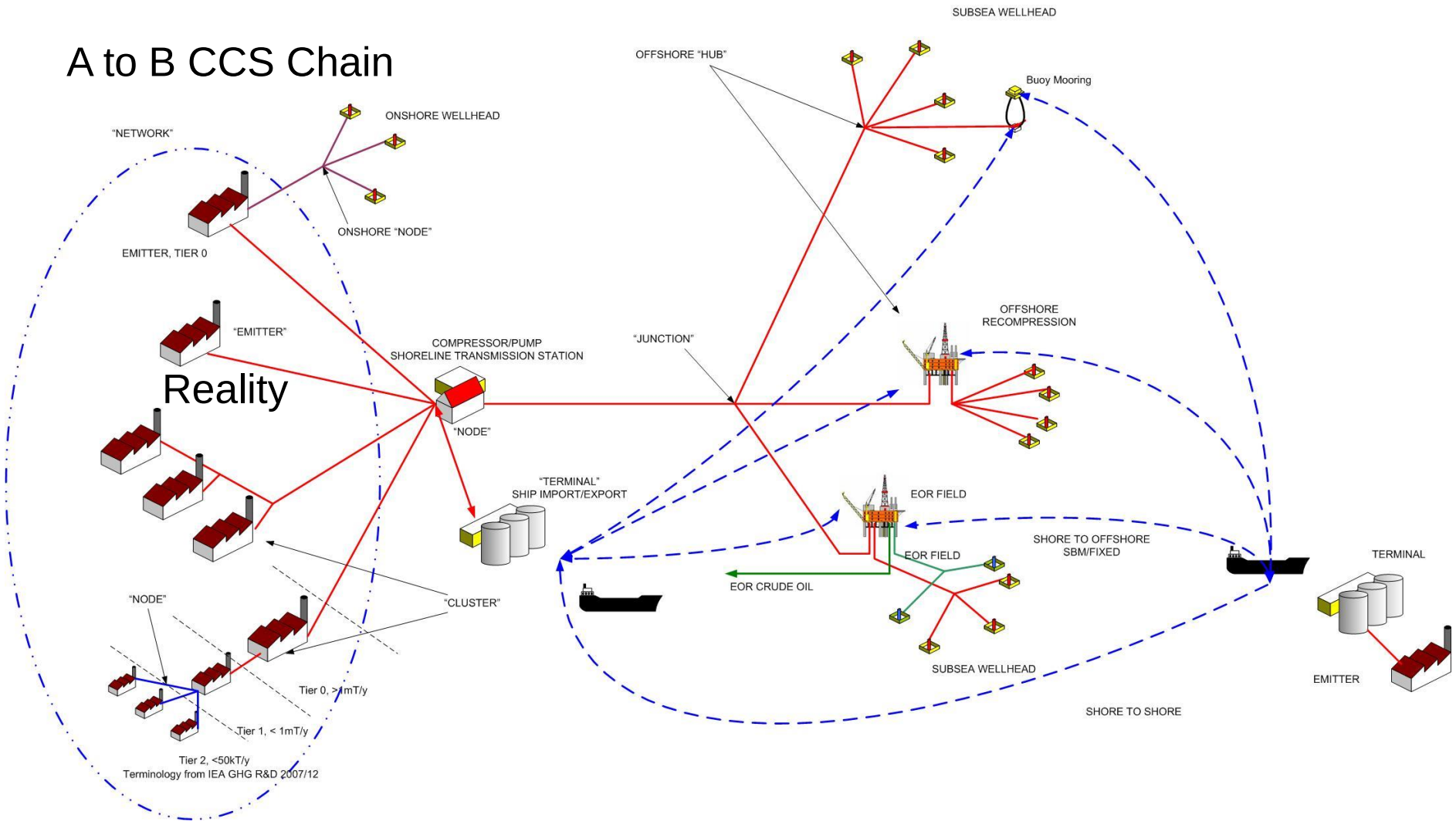
- Process integration
  - How do individual parts interact with each other
  - Can one part benefit another – for example heat recovery
- Control integration
  - How do you control the major elements in the chain
  - Who has responsibility
  - How do you flex a system to allow for a failure or slow down
  - Manage the full chain risk from the loss of an element
- Infrastructure
  - Single emitters
  - Multiple emitters
  - Single stores, multiple stores, in field variations across well heads
  - Third party access
  - Utilisation off-takes (somewhat in the future)

AMEC's Key Learning from previous projects

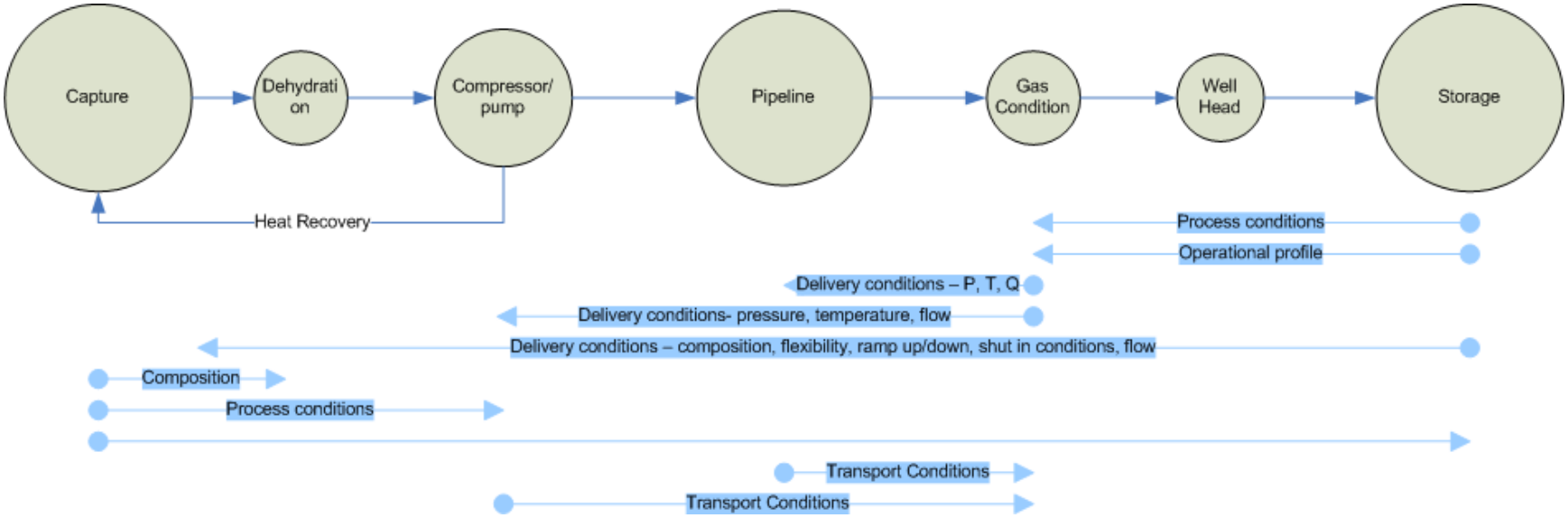
- Communication and collaboration plans
- Competency
- Requirements for good quality pre-FEED activities
- **Basis of Design – not transport specific, full chain**
- **Overall philosophies for scheme need to be considered**
- Significant culture issues in consortium
- **Reliability and Availability needs to be considered across the chain**
- **Flexibility impacts everyone**
  - **Compressors are not necessarily flexible**
- **Be realistic about;**
  - **Flexing**
  - **Impact of storage**
  - **Transport conditions**

CCS Networks

A to B CCS Chain



End-to-end influences on flexibility



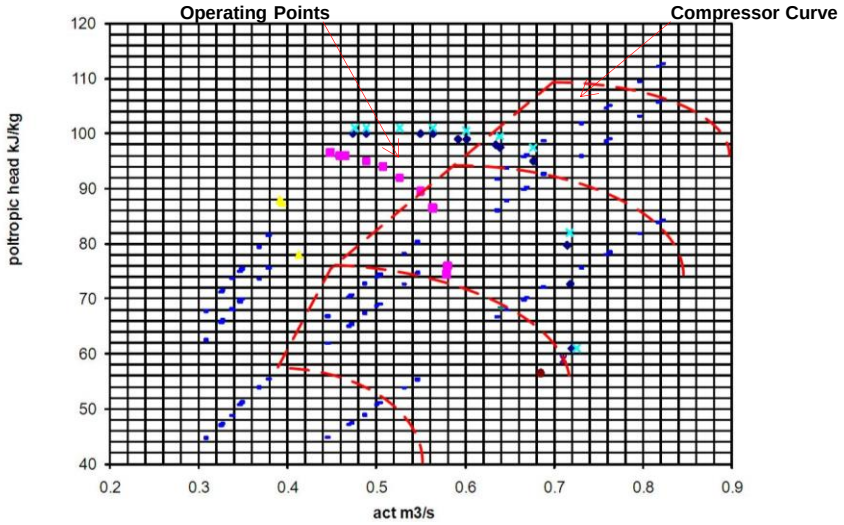
- Critical influences come from downstream and upstream sources (above)
- Requires high level information exchange and co-ordination
- End-to-end philosophies and specifications
  - Operations (including flexibility), control, RAM, Emergency, Start-up/shut-down, commissioning, composition specifications
  - Design basis at every battery limit

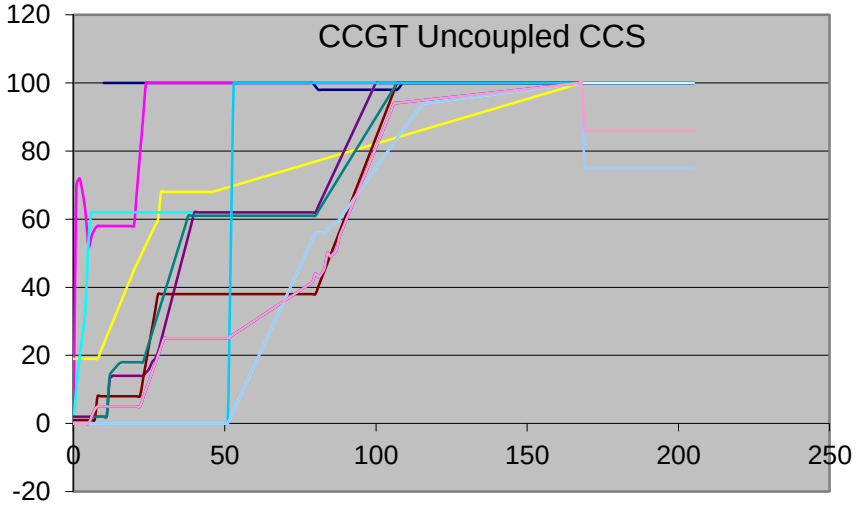
Key Issues

- Emitter/network load profile
- Flexibility requirements
  - Does the system need to respond over short or long periods
- Transport
  - Compressor/pump flexibility
  - Flexibility in the pipeline
  - Flow assurance
- Storage variations
  - What will a well pressure profile look like
  - Is it likely to vary much
  - Does it have set flow requirements – minimum flows are not uncommon
  - How will upstream activities like EOR impact flexibility

Flexibility

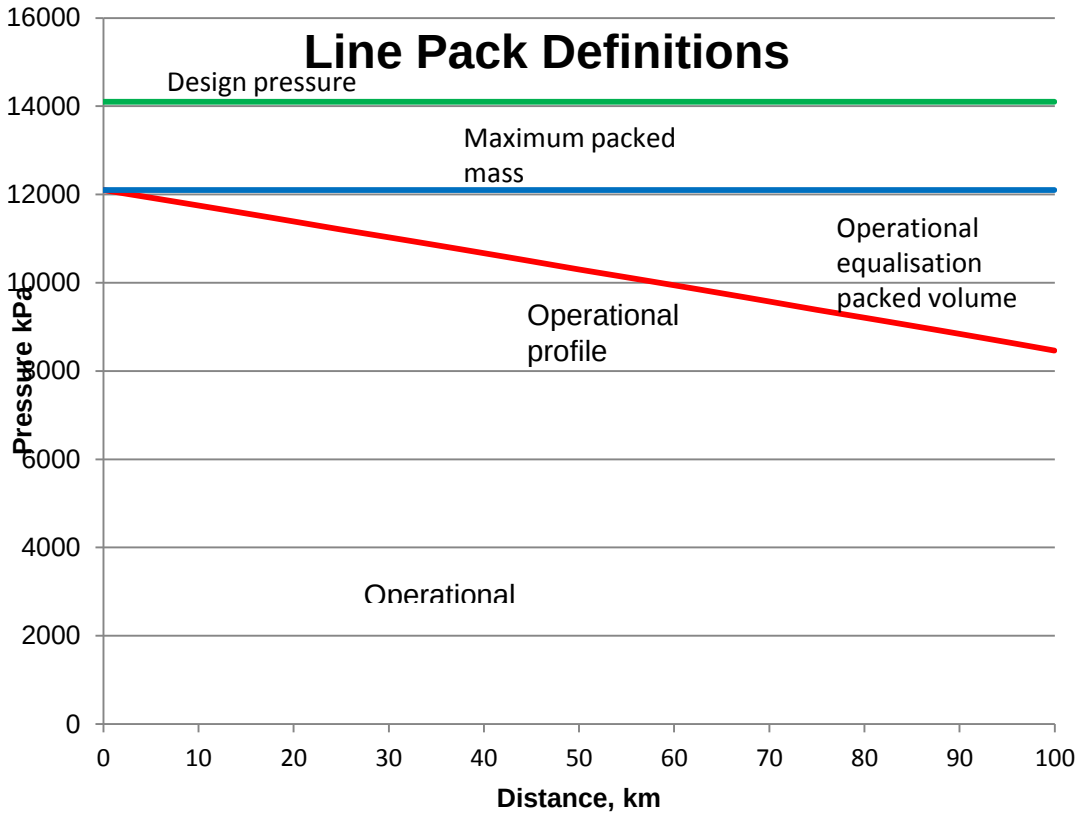
- Process flexibility
  - How well can the system adjust to flow changes
- Operational flexibility
  - How well can a system adjust to outages, reliability, composition changes, failures and start-up
- Not just about load factors
  - Flexibility can be caused by the store
  - Capture plant operating envelope
  - Pipeline capability (re-use)
  - Maintenance
- Impact of reliability issues
- Gaps in performance envelopes
  - Compressor operating ranges
  - Compressor inlet/outlet requirements
- Multiple emitter impacts
- Start-up/Shut-down



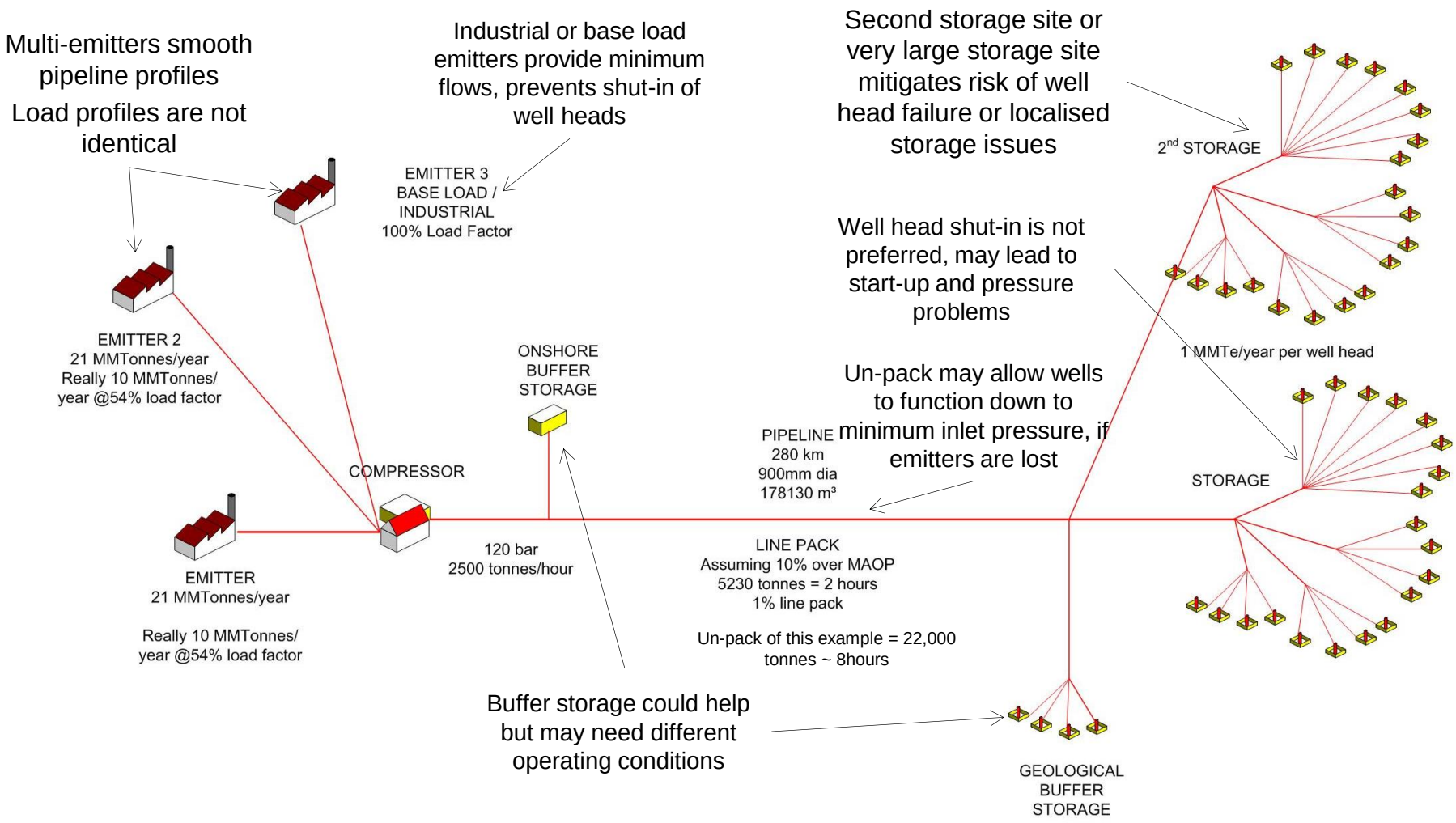


Flexibility in a pipeline

- Need to avoid two phase flow
- Pipelines can be packed or unpacked
  - packing supports emitters
  - unpacking supports stores
  - allows continued operation in upset conditions
- But its limited, a 36” pipeline for example, could hold a “flexible” capacity of only a few hours operation
- Do not have the same line-pack flexibility as natural gas

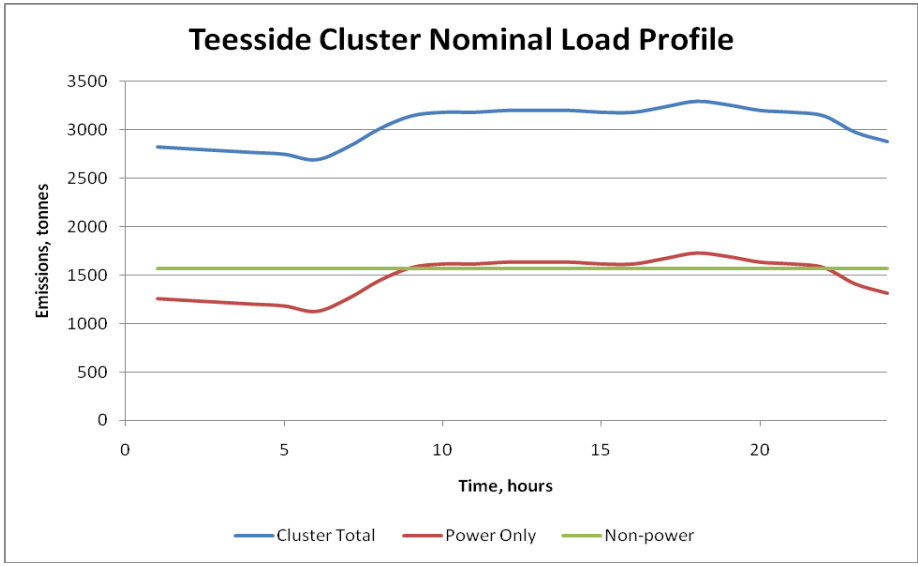


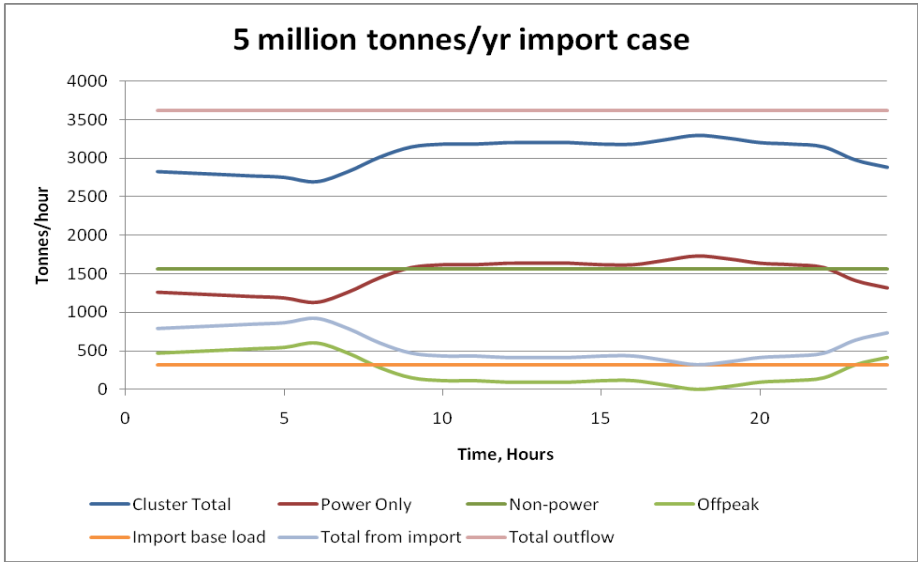
What options are there?



Large Infrastructures

- How does flexibility affect large clusters?
- Power only will lead to large variations if it is all peaking – not good
- Needs a mix of base load
  - Power
  - Industrial
- Could shipping or import from another network allow you to peak shave?
  - Requires storage





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