1) PETRONAS LNG Complex

- MLNG (1983)
- MLNG DUA (1995)
- MLNG TIGA (2003)
- Total 25.7 Million Tonnes Per Annum (MTPA) of LNG Production Capacity

![Image of the PETRONAS LNG Complex]

- Bintulu, Sarawak, Malaysia

2) MLNG DUA Debottlenecking

- Original Liquefaction Process (3 Modules):
  - Propane (C3) Pre-Cooled Mixed Component Refrigerant (MR) by Air Products and Chemicals Inc. (APCI)
- Opportunity for increased LNG Production capacity by 1.2 MTPA via:
  - Alleviating existing constraints in the Liquefaction Unit (C3 and MR Refrigeration systems)
  - Addition of Refrigeration capacity (New Extended End Flash Unit)
  - Addition of Power Generation System (New Gas Turbine Generators)
  - Tie-ins to existing utilities and common systems

3) Application of Dynamic Simulation in Liquefaction Debottlenecking Scope

- MR and C3 refrigeration circuits represent the heart of the LNG process. Assurance of process safeguarding is one of the prime concerns in the implementation of complex plant debottlenecking, particularly in the Liquefaction circuits.

Dynamic Simulation was carried out in two phases to address process safeguarding assurance:
- Phase I: During Project development (with MR/SCW Heat Exchanger)
- Phase II: Operations phase (without MR/SCW Heat Exchanger)

4) Benefits of Dynamic Simulation

- Better sizing of recycle valves and bypass valves based on actual failure scenarios compared to steady state
- Better insight gained into the integrated LNG process dynamics (post design commissioning)
- Start-up and shutdown procedures tested in advance of actual plant start-up. Start-up procedure were modified to keep machine away from surge and stonewall region
- Improved sequencing of recycle valves opening during Main Cryogenic Heat Exchanger (MCHE) trip to keep machines away from surge
- Confirmed governing plant flare relief loads at various operating scenarios and emergencies
- Demonstrates adequacy of existing relief valve to handle maximum relief at C3 circuit conditions beyond original design conditions
- Application of Dynamic Simulation is proven to be very effective in gaining very useful insights into the LNG process dynamics especially for complex plant debottlenecking.
- The study also helped to confirm further safe margin beyond existing design, particularly C3 circuit safeguarding, which is the governing case for existing flare design. This was pivotal in the optimized utilization of plant equipment in realizing increased LNG production capacity.

5) Conclusion

- Dynamic Simulation supports the realization of MLNG DUA debottlenecked capacity, which increased by 17.5% (1.2 MTPA).

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**3.1) Study Objectives**

- To confirm the operability of the LNG plant debottlenecking design for a range of different operating cases, failure scenarios and variety of different start up conditions and procedures
- To verify and ensure controllability of the compressors during unit upsets, start-up, shutdown and normal operation scenarios to ensure the safe operation and protection of the compressors against the potential risk of damage due to surge under all scenarios
- To estimate the compressor system's start up conditions and verify compressor systems' equipment design conditions

**3.2) Modeling Approach**

- Main Cryogenic Heat Exchanger (MCHE)
- Axial and Centrifugal Compressors
- Heat exchangers and chillers
- System volumes and resistance
- Anti-Surge Control (CC)
- Gas turbines and steam helper turbines

**Main Component**

- Modeling Approach
  - Main Cryogenic Heat Exchanger (MCHE)
  - Axial and Centrifugal Compressors
  - Anti-Surge Control (CC)
  - Gas turbines and steam helper turbines

**3.3) Study Work Flow**

- Kick-off meeting and input data gathering
- Build stand alone dynamic models for NO, MR and C3
- Dynamic models integration
- Model testing to ensure robustness
- Repeatability scenarios with the recommended changes
- Recommended changes demonstrated to be workable for all dynamic scenarios
- Prepare report summarizing results
- Final meeting to address comments and questions

**3.4) Benefits of Dynamic Simulation**

- Initial critical indication of compressor surge
- Final results: Compressor away from surge (post design changes recommended by Dynamic Simulation)

**3.5) Conclusion**

- Application of Dynamic Simulation supports the realization of MLNG DUA debottlenecked capacity, which increased by 17.5% (1.2 MTPA).