The Technical & Practical challenges of FLNG

SUT Evening Technical Meeting: "On the Fringes of FLNG", Perth 19/08/2015

Jeff Baker – Energy Compliance Technical Manager, Australasia

Lloyd's Register Energy

Working together for a safer world

Agenda

- Introduction
- Acknowledgement to Shell Australia
- Lloyd's Register and FLNG
- FLNG Challenges

Lloyds Register's role in FLNG

- Prelude - world's first Floating LNG Project.
  - FEED design review at generic & project specific concept stage,
  - Verification, Certification, Classification and Validation services.
- FLNG Rules annually reviewed - latest revision July 2015.
- Supporting publications including:
  - Surveys by ROV,
  - Risk based inspection for hull structures,
  - Risk based analysis for cryogenics spills,
  - Fire loading and protection,
  - Calculation of probabilistic explosion loads,
  - Technology Qualification.

Image courtesy of Shell Australia

FLNG Overview

Access stranded gas, using:

- Floating offshore or near shore structure permanently moored
- Subsea wells, via flowlines and risers (or other incoming supply)
- Fractionation and cleaning modules
- Liquefaction (refrigeration)
- Storage – LNG, LPGs and condensate (oil)
- Offloading - tandem or side by side

Image courtesy of Shell Australia

The Challenge

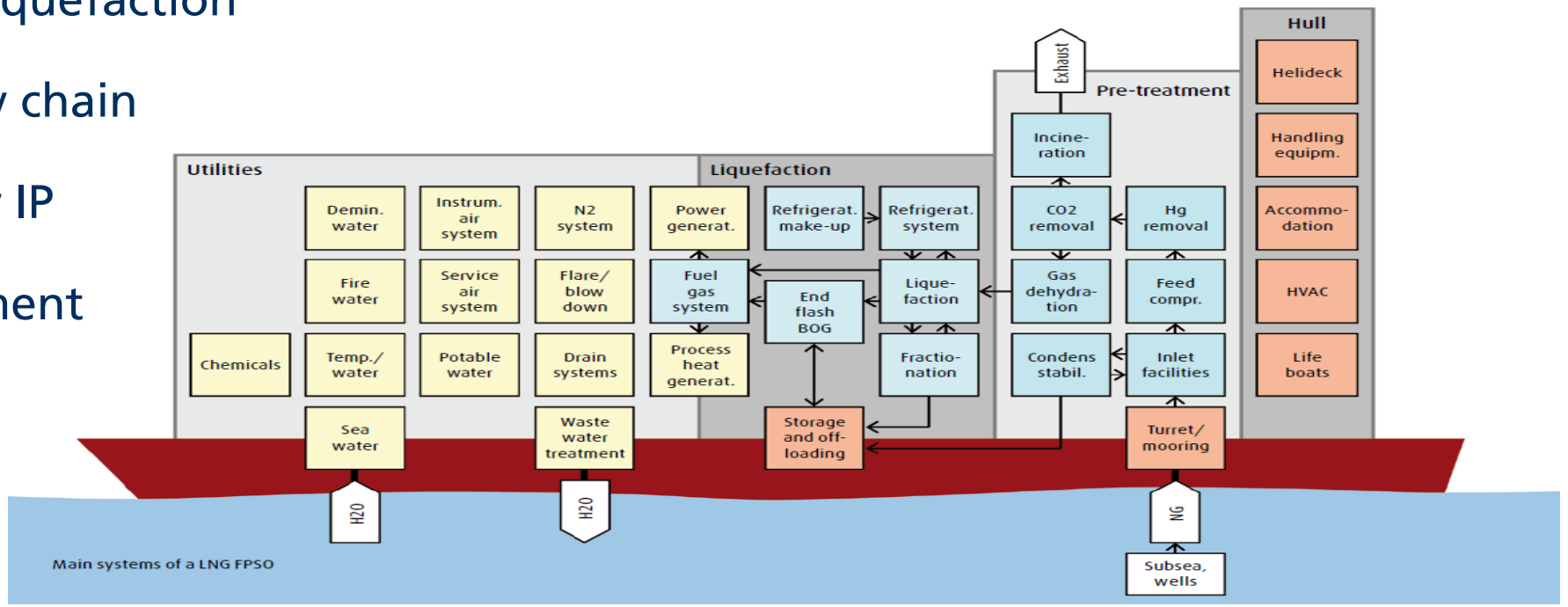
Combine new technologies, codes, standards and practice from three industries.

- Marine LNGCs
- Floating Offshore Installations
- Land based liquefaction

Complex supply chain

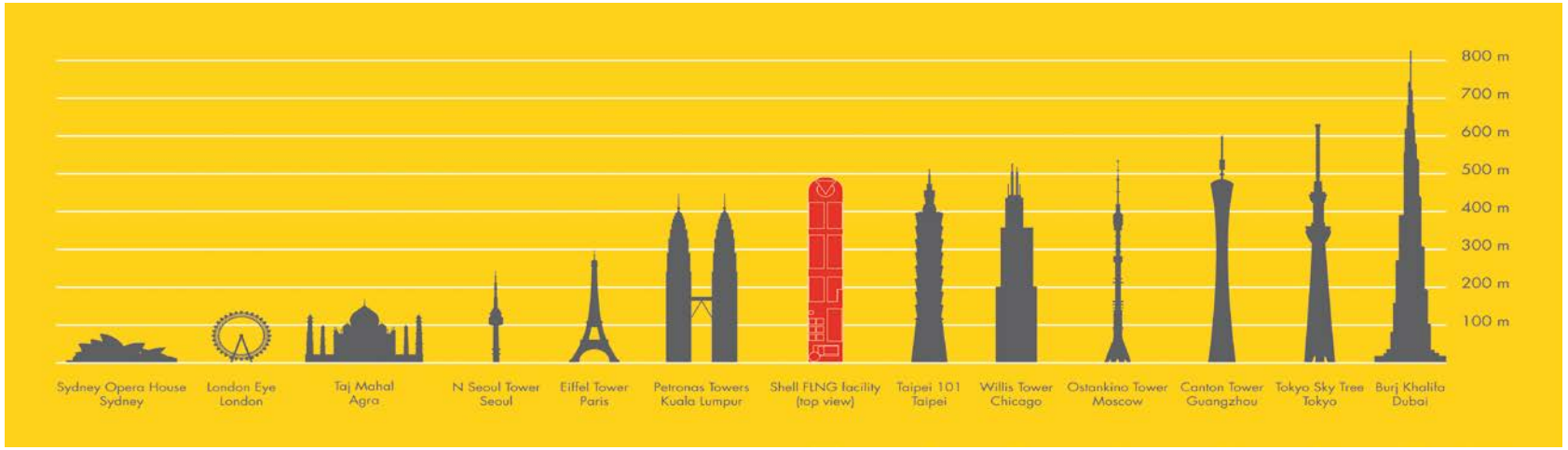
Significant new IP

Harsh environment



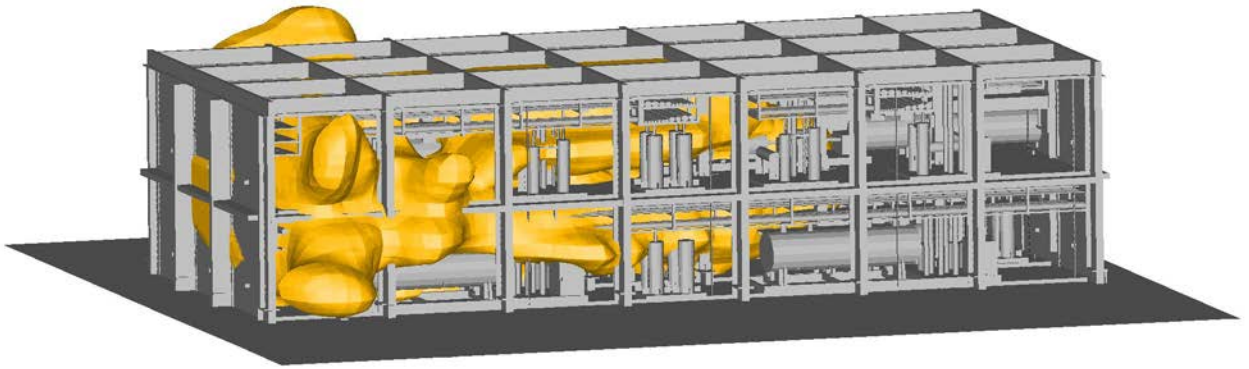
FLNG Design Issues

- New concept => risks associated with:
  - Process (restricted footprint versus land plant)
  - Vessel motions - effect on process plant
  - Process plant reliability (limited line pack available)
  - Storage of large quantities of process chemicals
  - Potential production and storage of multiple liquid and gas types
  - Managing Cryogenic fluids in proximity to large, critical hull structures



FLNG Design Issues

- Sloshing (dynamic loading of LNG CCS through filling range)
- Vessel strength and fatigue at fixed offshore location for (long) on station design life in harsh environments (e.g. Cyclone areas)
- Cooling water demands – uptake and discharge
- Very high Topsides – hull – turret loads
- Ballast tank hydrostatic head design issues
- Stationkeeping for offloading (tandem or side by side?)
- High mooring interface loads between FLNG and LNGC
- Very HV Power Generation and control - voltages beyond normal floating offshore and marine practice
- Fire and Blast challenges
- Dynamic Offloading Systems
- Regulatory issues

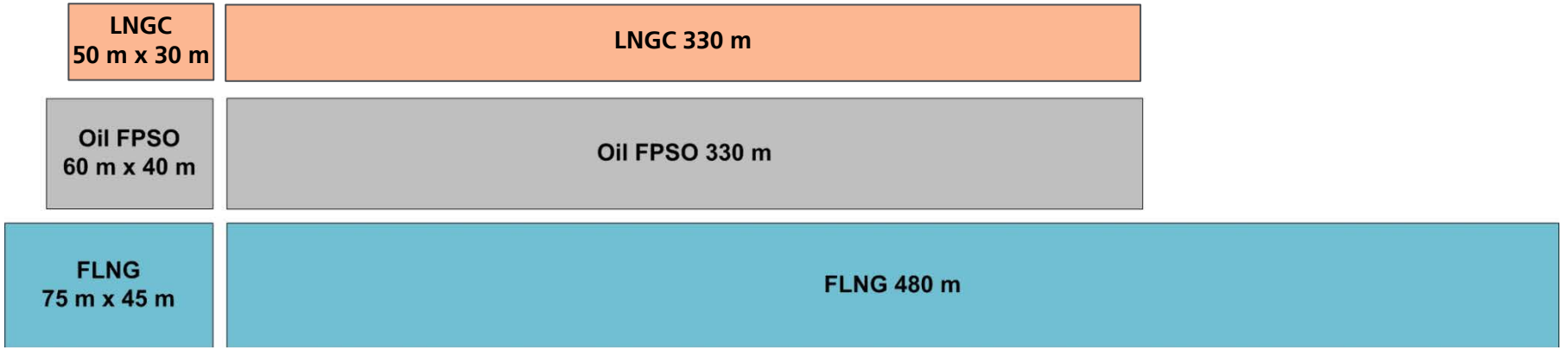


Challenges of Scale

Image courtesy of Shell Australia

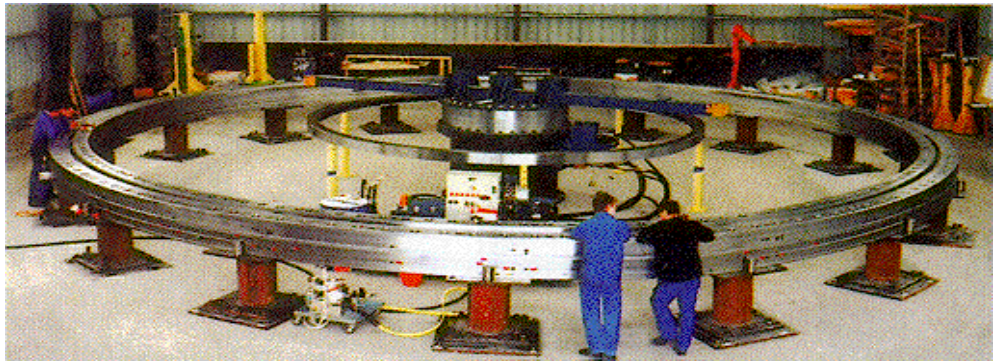
- Largest floating offshore facility in the world
- Production from 2 MTPA to in excess of 6 MTPA
- Deck size more than 4 football fields
- Hull/substructure:
  - Deck area equivalent of *four* typical FPSOs
  - Volume equivalent of *eight* typical FPSOs
- Topsides facilities – four to five tiered modules over the same deck area + accommodation block and turret
- Operating weight is six times largest aircraft carrier
- One quarter size of onshore equivalent plant
- Equipment stacked vertically for space optimisation
- Cargo liquids containment capacity of 175 olympic size swimming pools
- All operating permanently offshore in depths of water from 100 to over 1000 metres

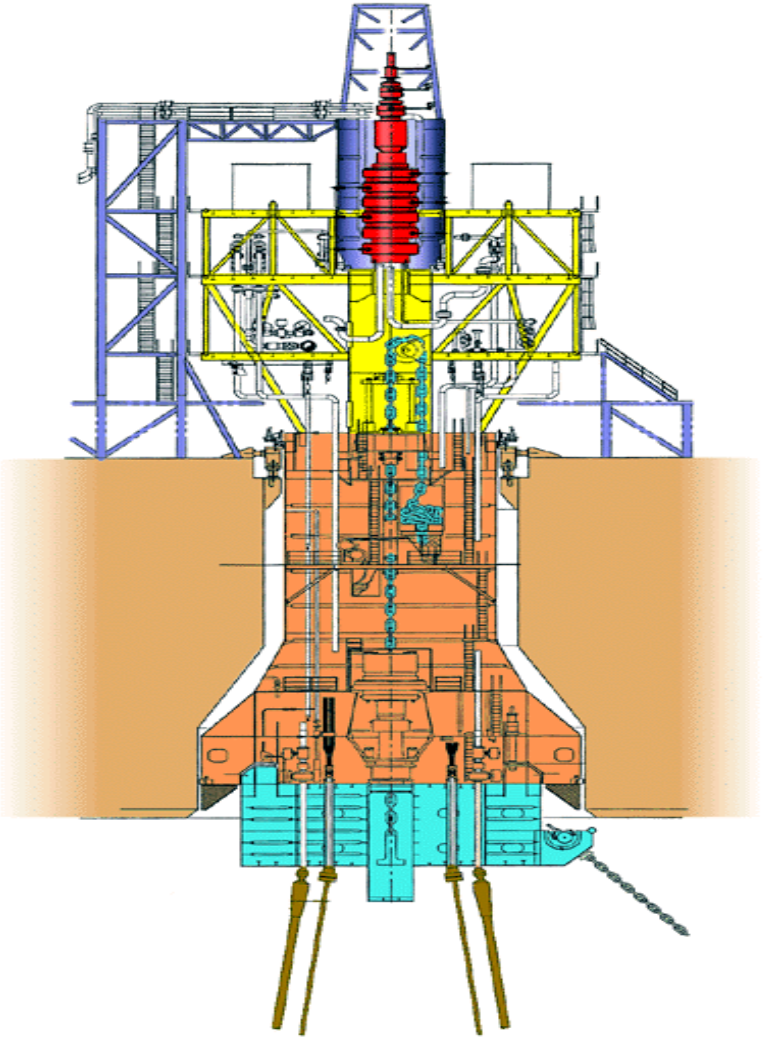
Size and scale versus current practice



Loads due to offshore outfitting

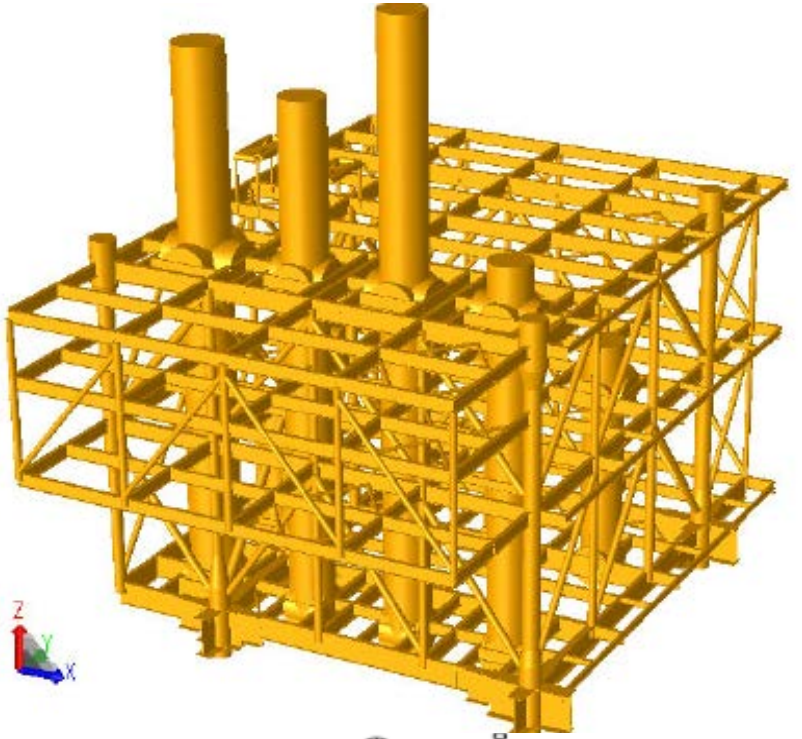
- Turret bearings
- Crane pedestals
- Lifeboat platforms
- Helideck
- Topside plant
- Flare stack

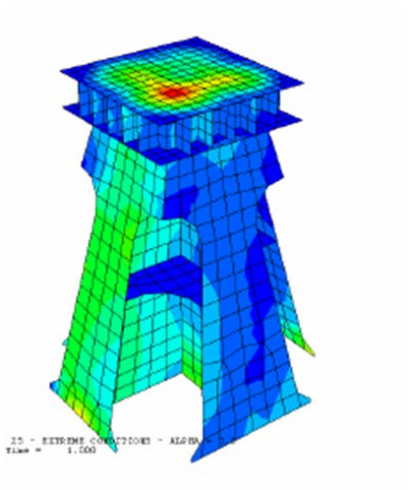


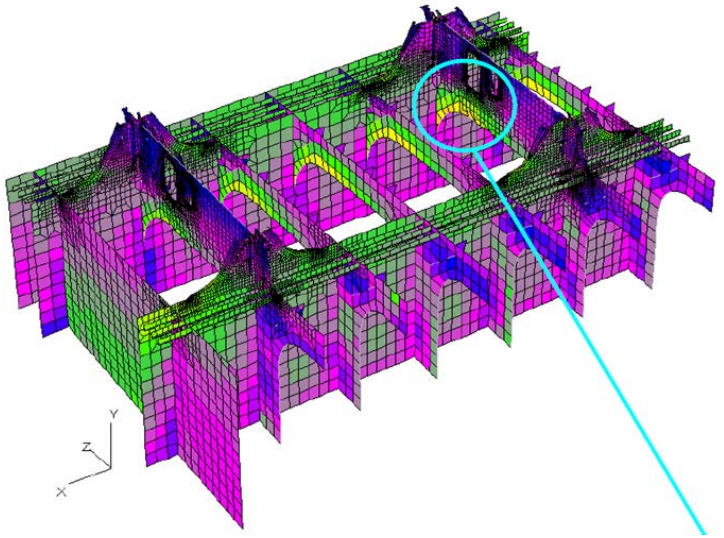


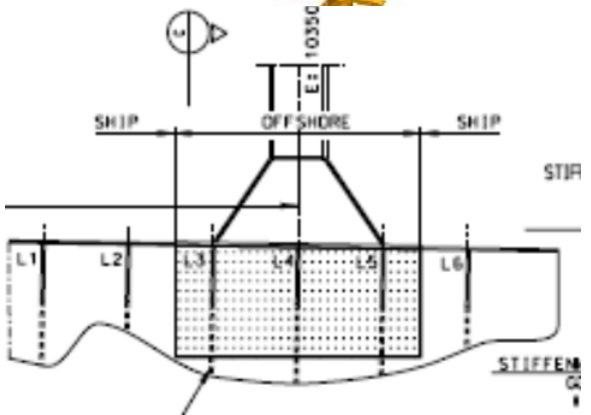
Topsides Layout and Loads

- Oil FPSO topsides – up to 40,000 tonnes?
- FLNG topsides – up to 90,000 tonnes?
- FPSO Module total typically 4,500t max, static reaction loads up to 1,250t, dynamic 2000t
- FLNG Liquefaction modules total 25,000 to 30,000t, dynamic reaction loads up to 4,000t









Comparison of marine containment systems

Membrane

- No cool-down rate limit
- Good visibility from bridge
- Space efficient
- Flat deck area is potentially beneficial for FLNG
- Design company available for in-service advice
- Complex - Integrity of containment system depends on quality from many sub-contractors
- Potentially vulnerable to partial fillings - sloshing damage

Moss

- Less chance of damage by mis-operation
- Primary barrier fully gas-tight
- Visible secondary barrier
- No barred fill ranges
- Easier access for repair
- Expensive build facilities at shipyard
- Domed tanks give poor deck area for FLNG and bridge visibility issues

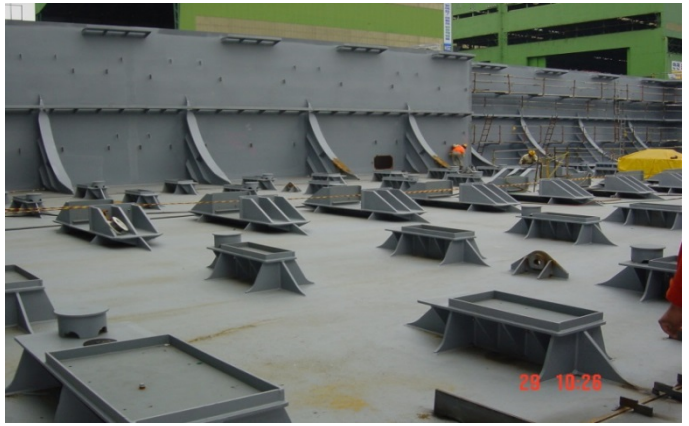
SPB

- Same as Moss, but:
- Good visibility from bridge
- Flat deck area is potentially beneficial for FLNG
- Prefabricated, possibly offsite
- More space efficient than Moss
- In-service experience limited

Marine LNG Containment Systems suitable for FLNGs

Membrane Systems

Independent Tanks



Prismatic (SPB)

- Stainless steel
- Aluminium alloy

(Also used for LPGs)

Offloading Systems

- LNG
  - Side by side
  - Tandem Over-the-stern
  - Remote
- LPG
  - As LNG
- Condensate
  - Hose reels
  - Floating hoses over- the-stern

Safety aspects - Cryogenics

- Trading gas carriers - Only manifold section needs to be considered:
  - Used periodically with loading arms connected and disconnected in benign conditions

- FLNG more complex - LNG rundown into storage tanks and liquefaction processes in constant use and at cryogenic temperatures

ANY QUESTIONS?

Jeff Baker,
Energy Compliance Technical Manager, Australasia

1st Floor, 503 Murray Street, Perth WA 6000
T +61 8 9318 7300
E Jeff.baker@lr.org

Lloyd's Register Energy

Working together for a safer world