
**Paper title**

# Australian Lessons for Developing & Delivering Large and Complex Projects

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**Synopsis**

Independent Project Analysis, Inc. (IPA) reported in 2009 that 74% of completed Large and technically Complex Projects they had assessed in Australia had been failures, mostly due to pre-execution causes.

In 2012, PwC reported that only 2.5% of Australian companies delivered their projects with their planned scope, within time and cost targets and with planned benefits. Of the remainder, nearly 90% of the failures were due to managerial causes.

Other exacerbating factors are discussed.

Despite these effects, such was the strength of rising demand from China in particular that rising commodity and energy prices rescued many resource projects, until about mid-2012.

Performances of mining & LNG projects and their futures are discussed, with examples.

**What can be done to help Australian sponsors successfully develop major projects in future?**

One lesson seems clear, whether the projects are resource or infrastructure based: front end planning of projects must be managed more competently. This means performing sufficient studies and engineering to produce comprehensive definition of scope and understanding of the risks inherent in the project whether internal or external.

This paper extends the use of Monte Carlo Method Integrated Cost & Schedule Risk Analysis (IRA), proven on a number of complex and mega projects, to propose an approach that covers all the above uncertainties. It incorporates the operational life of the project as well as stages from Concept through Execute to Startup and adds operational and revenue uncertainties and risks to design, construction and commissioning uncertainties and risks. It is called Integrated Costs, Schedule & Revenue Risk Analysis (IRRA).

The advantage of IRRA is that it is capable of integrating ALL time, cost and revenue uncertainties, risk factors and risk events, moving over a backdrop of seasonal weather uncertainties and cyclical market fluctuations (including commodity prices and interest rates), to provide comprehensive modelling capabilities for producing probabilistic NPVs and IRRs. Exploration of sensitivities can be used to test the resilience of the project economics. The probabilistic balance between success and failure can thus be evaluated. A demonstration project illustrates the methodology.

# Contents

# 1. Australia's poor large project performance

Now that the resources boom has passed its construction peak we can review the overall record and also examine a number of major and mega projects and draw some useful conclusions from their trajectories from concept through execution to operation insofar as information is available.

## 1.1 Assessments of Australia's Poor performance

Independent Project Analysis, Inc. (IPA), reported (Young, 2009)[i] that 74% of completed large and technically complex projects they had assessed in Australia had been failures. Most of the causes were assessed to have occurred early in the pre-execution phases for a range of reasons including poor organisation, scope development, execution strategy and unrealistic cost and schedule targets. IPA concluded that the removal by Australia's process and resource companies of their central engineering and project capable departments in the 1990s had removed the capabilities of those companies to develop technically complex projects (if they had ever had them).

In late 2012, PricewaterhouseCoopers (PwC) reported[ii] that only 2.5% of companies delivered their projects with their planned scope and within their time and cost targets and delivered the expected benefits. And of the remaining 97.5%, only 8% of the failures to meet objectives were due to technical aspects – the rest directly related to managerial aspects.

It is important to set Australia's performance in the global context. An August 2014 report by Ernst & Young Global on worldwide Oil & Gas Megaprojects[iii] shows that 64% exceed budget (on average 59% above initial estimate) and 73% miss their schedule targets. The performance varies regionally:

| Region: | Overall | North America | Europe | Asia-Pacific | Middle-East | Africa | Latin America |
|---|---|---|---|---|---|---|---|
| Value US$ bn | 2,576 | 482 | 379 | 945 | 206 | 350 | 214 |
| % of projects cost overrun | 64% | 58% | 53% | 68% | 89% | 67% | 57% |
| Average % overrun from Initial Estimate | 59% | 51% | 57% | 57% | 68% | 51% | 102% |
| % of projects schedule overrun | 73% | 55% | 74% | 80% | 87% | 82% | 71% |

We can conclude that the problem of large project overruns is global but that Australia's performance is far from exemplary.

It is well known that infrastructure mega projects in Australia have drastically overrun in time and cost as well as resource mega projects. Recent examples include the Victorian Desalination Plant, Airport Link in Brisbane, Myki Smartcard ticketing system for Melbourne's Public Transport System, Sydney's Cross-City Tunnel and the Brisbane Clem 7 Tunnel (the latter projects also examples of significantly over-estimated revenue). This paper focuses on private sector resource projects while recognising that many of the lessons are applicable to infrastructure projects also.

## 1.2 Examples of under-performing projects

The author had first-hand experience of each of the following projects in various roles and is using them to illustrate some lessons learned regarding the development and execution of mega projects

### 1.2.1 BHP HBI Project (1995-1999)

#### *1.2.1.1 Pre-Financial Investment Decision (FID) Issues*

The project was run by BHP Iron Ore (IO), an operating division of BHP, without experience of running complex process plant projects.

The plant was based on a Venezuelan Direct Reduction of Iron (DRI) plant that had been plagued by problems when first built. It was only able to run acceptably after an Austrian company extensively modified it in the early 1990s.

BHP was so keen to acquire this technology to take advantage of booming construction conditions in SE Asia in the mid-1990s that they committed to the project with inadequate testing using Pilbara feed material. They also struck a contract with the Austrian company that was quite favourable to the plant designer.

The capital estimate was too high to meet the BHP Board's benchmark IRR of 15%, so IO reduced it substantially to ~$1.6bn indicating they would "achieve savings during project execution".

#### 1.2.1.2 "Self-Execution"

When savings had not been achieved through engineering and procurement, at the time of appointing a construction contractor, IO decided to save on construction risk allocation by changing to an alliance model. "HBI Alliance" was intended to share risk between BHP and the three construction contractors. Instead BHP took on all the risk and the project became a large reimbursable manhours project with commissions paid to the three contractors for hired equipment and a substantial excess of equipment being hired for project use. Figure 1 below shows the HBI DRI plant and associated Synthesis Gas Plant during construction.

#### 1.2.1.1 Lack of Effective Project Planning and Control

IO did not understand the role of project planning and assigned it to the contractors.

Although IO included a daily countdown calendar to first product on their project correspondence, they did not have an Integrated Master Control Schedule (IMCS) to verify that they would achieve the target date. Indeed until only a few months before the target date they continued to assert that the target date would be achieved, whereas it was achieved about a year late after the BHP Board dismissed the heads of BHP Minerals and IO for "failing to keep the board informed".

#### 1.2.1.2 Rescue Project Management Team

A rescue team of project people headed by senior BHP Engineering personnel was appointed by the BHP Board to complete the project. They had to grapple with setting up effective processes and deal with a myriad of problems caused by the previous project leadership lacking requisite experience to manage a megaproject. A couple of the problems in which the author was involved are described below.

#### 1.2.1.1 Integrating the project schedules

The rescue team had to create an integrated critical path schedule for completion of the project to integrate separate schedules for each of the three main contractors plus the detailed commissioning schedule and replace a separate summary schedule representing the project for use by the senior project management team.

Figure 1: BHP HBI Project during construction
Source: http://www.lowther-rolton.co.uk/Projects/Australia/BHPHotBriquettedIronProject/tabid/148/Default.aspx

#### *1.2.1.2 Utilities Systems not designed for startup*

After wall-papering a site hut office with logic diagrams from the newly-integrated schedules, the planning team concluded that the HBI plant had been designed to operate but not to be started up. There were a series of ring mains for utilities around the plant without isolation valves. This meant that the utilities piping to all sections of the plant would have to be completed before the plant could be started, greatly delaying the planned progressive commissioning and startup of systems that commenced with utilities. As a result modifications were made to add in isolating valves from the ring mains to the various plant sections.

#### *1.2.1.1 Change in Market Conditions*

During construction, the 1997/98 Asian Financial Crisis occurred, causing precipitous falls in the values of currencies of SE Asian countries such as Thailand, Malaysia and Indonesia in particular. This wiped out the growth conditions that drove the BHP strategy to build the HBI plant as a supplier of feed material for Electric Arc Furnaces to be built in the SE Asian countries to supply the high growth construction sectors. It caused the value of Hot Briquetted Iron to drop substantially.

#### *1.2.1.2 Commissioning and Operating Problems*

This remarkable combination of synthesis gas, direct reduction fluidised beds and briquetting plants, of about 25,000 tonnes and 100 metres high was mechanically completed in Q1 1999.

Commissioning of the HBI plant was plagued with problems, most seriously that the FINMET process (Whipp, 2009)[iv] was unable to completely reduce the iron oxide to iron metal due to the formation of a dense outer layer preventing reduction of the core. It was intended to produce >2 million tpa but was never able to reach that rate. It started to make money when the price for HBI product exceeded US$200/t in 2003/4.

But the sticky behaviour of the partially sintered particles caused buildups of agglomerated material wherever there were lodging points in the vessels and ducting. More dangerously, the formation of a dense outer layer (probably of Iron Carbide) around agglomerations trapped explosive synthesis gas (including hydrogen). Despite the use of inert gas to reduce the risk of explosions, a maintenance worker was killed and two others seriously burnt in May 2004 when cleaning out one of the four process units.

#### *1.2.1.3 Final Project Outcome*

The plant was shut down and never re-opened. The full US$2.5bn cost had already been written off by BHP and in 2011 the plant was dismantled by explosives and systematic reduction to scrap, as shown below in Figure 2.

Figure 2: BHP HBI Process Plant brought down by explosives and reduced to scrap
Sources: http://pilbara.me/tag/port-hedland/ & http://www.genesisattachments.com/u_boodarieironplantaustralia.asp

The experience of HBI and other failed projects such as a platinum project in Zimbabwe and a mineral sands project in southwest WA did not stop the BHP Board from subsequently following the business re-engineering movement led from USA in the 1990s by selling off their repository of project execution skills a couple of years later. In fact BHP was one of the last major Australian companies to sell or disband their major project execution organisations.

### 1.2.2 BHP Ravensthorpe & Yabulu Projects (2004-2008)

#### *1.2.2.1 Introduction*

BHP was determined to expand its nickel production following acquisition of WMC's nickel business, as part of its goal of only being in Tier 1 assets. Metallurgically, the simplest nickel ores to process, magmatic sulphides, are in increasingly short supply and mostly the more difficult lateritic nickel ores are available, which required high pressures, acidity and temperatures to extract the nickel concentrates (Robinson, 2012)[v]. A limited life lateritic ore body was available near Ravensthorpe in SW WA which required the above still novel processing. BHP Billiton had inherited a 30 year old nickel refinery from Billiton in Townsville which it decided to upgrade substantially to process concentrate from Ravensthorpe.

BHP engaged the company which had bought its engineering organisation to be the EPCM contractor for both linked projects.

When announced in March 2004, the combined Ravensthorpe and Yabulu projects were estimated to cost US$1.4bn and deliver an extra 44,500 tonne/y of nickel and 1,400 tonne/y of cobalt from the Yabulu Refinery giving totals of 76,000 t/y of nickel and 3,500 t/y of cobalt. The first shipment of concentrates from Ravensthorpe to Yabulu was forecast to occur in Q2, 2007 and the first Yabulu metal production from those concentrates in Q3 2007. The actual performance of the two projects was rather different.

#### *1.2.2.2 Ravensthorpe*

The process chosen was still not fully proven at production scale and required High Pressure (Sulphuric) Acid Leaching (HPAL). The Ravensthorpe Nickel Concentrator site during construction is shown in Figure 3 below.

Design, procurement and construction of the project required several re-baselinings and there was a lot of interference by BHP in process finalisation and equipment definition and selection, along with approval delays. The project had to go back to the BHP board multiple times for additional funding and completion was delayed substantially. While the EPCM contractor was far from blameless, they submitted claims to BHP for hundreds of thousands of extra manhours based on delay and disruption.

Figure 3: Ravensthorpe Nickel Concentrator during construction
Source: http://www.ertech.com.au/experience/resources-experience/ravensthorpe-nickel-project/

The mine and processing facility were completed in late 2007 at a cost of US$2.2bn and started up with difficulties. They were officially opened in 2008, with production expected to reach 50,000 t/y of included nickel.

The Ravensthorpe rampup coincided with the Global Financial Crisis and a severe decline in the price of nickel, as can be seen from Figure 4 below from the London Metals Exchange. The price dropped to around US$10,000/tonne, less than 1/5th of the peak price of ~US$54,000/tonne in 2007:

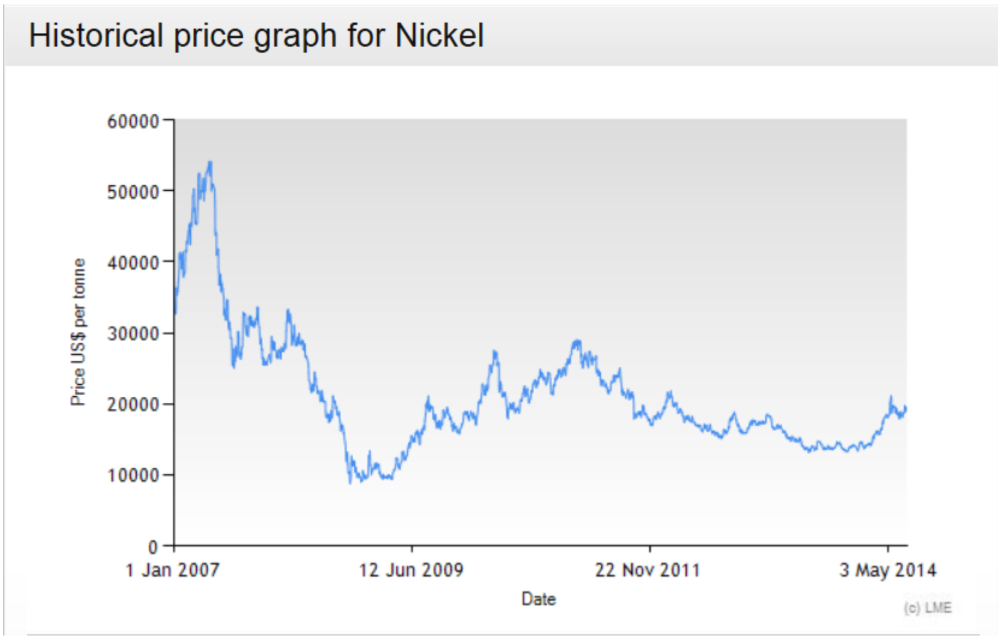


Figure 4: LME Price of nickel, 2007 to 2014

In January 2009 (around the time of the minimum price for nickel), BHP Billiton shut down the Ravensthorpe mine and plant, after less than a year of operation, and put them on the market.

#### *1.2.2.3 Yabulu*

A similar story unfolded with the Yabulu Nickel Refinery near Townsville. The 30 year old Greenvale nickel refinery was more than doubled in size in a brownfields expansion to handle the nickel concentrates to be produced from Ravensthorpe. The project had a number of interfaces with the existing operating refinery, which greatly complicated the construction, as did the need for extensive refurbishment of the original refinery. Approval delays and design changes from the owner / operators, along with chronic delays to provision of certified vendor data required for model finalisation and issuance of AFC drawings resulted in cumulative disruption of the project. Again claims were submitted to BHP for hundreds of thousands of extra manhours.

See an aerial view of the Yabulu Nickel Refinery in Figure 5 below.

Figure 5: Yabulu Nickel Refinery
Source: http://trility.com.au/projects/qni-yabulu-reuse-plant-reference-site/

Yabulu received its first mixed hydrate matte from Ravensthorpe in early 2008. After less than a year of production, the matte-processing stream in the refinery was shut down in January 2009, concurrent with the shutdown of Ravensthorpe.

##### *1.2.2.4 Final Project Outcomes*
In July 2009 BHP Billiton sold the Yabulu Nickel Refinery to Clive Palmer for an undisclosed amount and wrote down the carried value of the refinery by US$500m and a further US$175m in unrecoverable tax losses.

At the end of 2009, BHP Billiton sold the Ravensthorpe mine and plant to Canadian company First Quantum Minerals for US$340m. After 18 months of modifications and recommissioning, the mine and concentrator re-opened, producing nearly 33,000 tonnes of included nickel in its first full year of operation in 2012.

The write-downs by BHP Billiton for Ravensthorpe and Yabulu totalled US$3.6bn.

The acquiring companies now owning and operating the mine and the refinery appear to be making a success of them in market conditions where product can be sold at around twice the price that prevailed when BHP shut down the ventures. They were able to purchase major facilities at highly discounted prices.

#### 1.2.3 Woodside Pluto Project (2007-2012)

##### *1.2.3.1 Introduction*
Woodside Petroleum Ltd were proud of their relatively quick development of the Pluto project from initial field discovery in 2005 to FID and construction of the facilities. Compared with other greenfields LNG projects, it was initially very speedy. The scope of the project provided for 5 subsea wells from the 4.5 TCF Pluto and Xena gas fields in 800m of water 180km offshore from the Burrup Peninsula to supply a 4.3 MTPA single train LNG plant. This was Woodside's first 100% owned LNG project.

In November 2006, at an Industry Briefing on the project, Woodside accurately forecast Financial Investment Decision to occur in July 2007, but optimistically forecast First Cargo could occur in October 2010, a project duration of only 39 months. The project took much longer.

See Figure 6 below showing the Pluto onshore LNG plant construction site.

Figure 6: Pluto LNG Plant nearing completion
Source: http://www.perthnow.com.au/business/woodsides-pluto-project-finally-ready-to-roll/story-e6frg2s3-1226307656878

##### *1.2.3.2 Pre-Financial Investment Decision (FID) choices and consequences*
The front-end planning of Pluto by Woodside was performed in a short time (FEED started September 2006, FID July 2007). It is understood that Woodside management made a conscious decision to proceed to FID and execution phase with minimal delay, in their desire to bring the gas to market as early as possible.

Woodside and their Onshore EPCM Joint Venture contractor for Pluto, Foster Wheeler (60%) Worley Parsons (40%) (FWWP) were in an integrated team relationship for NW Shelf LNG Train V completion and startup (starting up in 2008), which were happening in parallel with the early stages of Pluto. Woodside management established a conventional EPCM contract with the FWWP JV for Pluto.

The complexity and scale of the challenge of assembling skilled and experienced engineering resources to design and manage the procurement and construction of the onshore facilities in a stretched project environment in Australia and elsewhere in offices servicing the Australian market resulted in material problems and delays to the onshore scope as described below.

#### *1.2.3.3 Engineering, Logistics & Quality Problems*

These problems of complexity and over-stretched resources showed up initially in late engineering and procurement. As is now normal for such complex plants, the plant was modular in design, to maximise fabrication and pre-assembly in more efficient and lower unit cost module yards in SE Asia and minimise expensive site construction labour costs. However, this imposes tighter deadlines on engineering and procurement to ensure equipment is designed into modules and the equipment and materials are specified and procured in time to be installed in the module yards for scheduled shipment to site.

The materials had to be available in time to achieve the required installation schedules in the modules to comply with the fixed shipping schedules of the large module carrier vessels which shuttled between the yards and the Burrup Peninsula to deliver the modules (see Figure 7 below). Due to late engineering and procurement, FWWP / Woodside were faced with a difficult choice of shipping modules incomplete, to be completed on site, or delaying the module shipments until the materials were available, thus incurring delay costs from the shipping company and additional charges from the module yard owners, who had following work from other clients and restricted space for storage. As a consequence, carry-over work and completion of work out-of-sequence in the modules on site became a major issue.

This situation was made significantly worse by module quality problems requiring substantial rework onsite[vi]. A further exacerbating factor was the increased difficulty of installation work inside modules compared with non-modularised plant. It has been estimated for all such modular construction that 100 manhours of work in a module yard, where the modules are spread out for assembly access, requires 200 manhours of work on site where the modules have already been assembled. This is quite apart from the substantially higher cost of labour on site.

The increased site work was quarantined from the main project team. The integrated project team option used on NWS Train V was implemented and a task force run in parallel to manage the out-of-sequence, carryover and rework, so that the main project management team was not diverted from completing the project.

Figure 7: Pluto Process Modules being unloaded at Burrup Peninsula from special transporter ship
Source: http://www.theaustralian.com.au/archive/business/woodside-petroleum-backs-off-pluto-fid-expansion-target/story-e6frg9ef-1225896105321

#### *1.2.3.4 Reduction of Team Motivation by Project Plan*

Like the HBI project, the Pluto Project used a countdown calendar, in the Pluto case to “Ready For Start Up” (RFSU). The publicly announced target onshore RFSU of 27 Aug 2010 was unable to be met because of the above engineering, logistics and quality problems and industrial disputes that followed late in 2010 and 2011. This meant that the countdown calendar lost its utility as a motivator for the project team and the schedule behind it was at risk of ceasing to be a useful guide for the project team until it was re-baselined.

#### *1.2.3.5* Industrial Relations Consequences of Acceleration of Work Attempts

The previously mentioned out-of sequence, carryover and rework requirements put great pressure on completion of the onshore scope because the authorised and prepared construction area was quite restricted and the remote location imposed strong accommodation constraints. To deal with the added workload and the need to increase manning to minimise slippage, in late November 2009, Woodside changed the accommodation rules from one room for exclusive use of each worker to "motel-style" accommodation, where worker's personal belongings were stored, but when each worker went on R&R, another incoming worker would take their place. This freed up 25% of the accommodation, but also caused a major industrial dispute in January 2010 and significant delay to the project.

The Fair Work Act 2009, implemented in July of that year, gave unions the right to access work sites (a right explicitly denied by the Labor Party that they would grant, prior to the 2007 election), which until then had been unavailable at the Pluto site. From 1Jul09 to 27Oct09, the four major unions eligible to represent the workers entered the site 217 times and by May10, 450 times.[vii]

Also in January 2010, the CFMEU initiated a claim to organise a "28 day protected action stoppage" of crane and forklift operators in support of a new Enterprise Agreement. After Fair Work Australia authorised a protected action ballot in March, the ballot resulted in a 28 day stoppage from late April 2010. This dispute continued with lockouts and stoppages until August.

Industrial action may have added 6 months to the Pluto construction duration.

#### *1.2.3.6 Offshore Costs Blowout*

Offshore costs blew out significantly, driven more by labour rate increases and work practices than prolongation costs. A comparison of Average Weekly Earnings for Australia as a whole and for the Mining sector labour rates with Offshore Hydrocarbons construction rates between 2005 and 2011 in Figure 8 shows a stark difference:

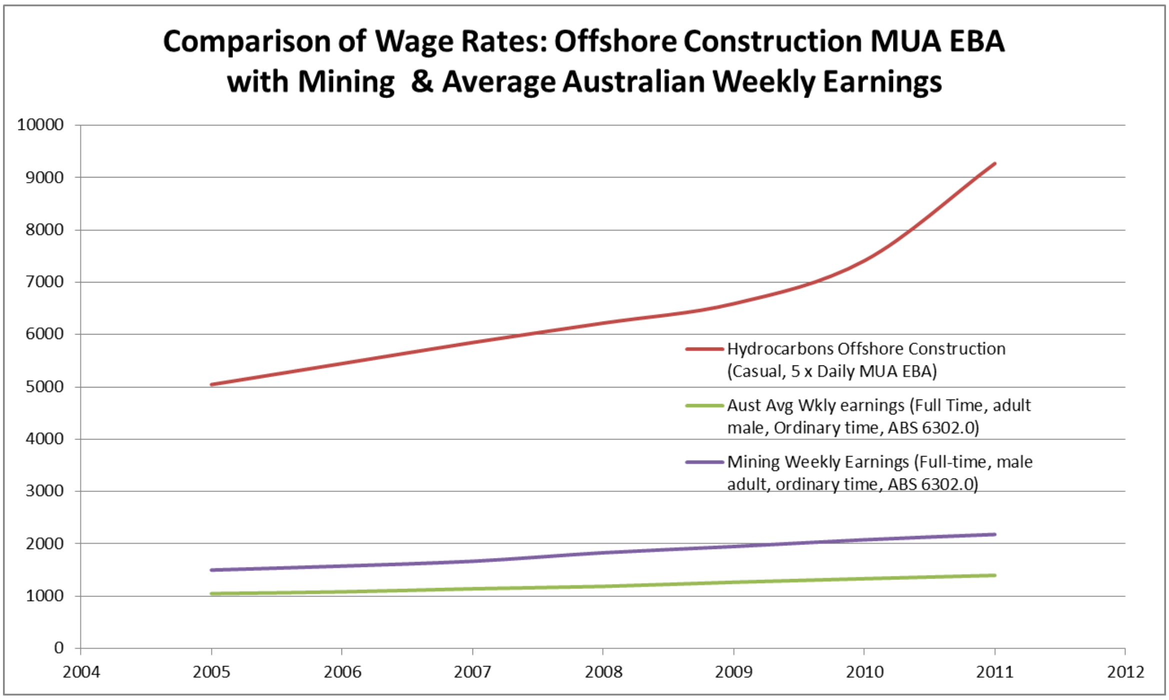


Figure 8: Comparison of Offshore Daily Rates x 5 with mining & Australian Weekly Earnings
Source: Stuart Wood SC "Lessons for major projects under the Fair Work Act" HR Nicholls Conference, Tuesday 12 June 2012, Melbourne; & ABS

The Weekly Offshore Construction rates have been derived by multiplying the MUA EBA daily casual rates by 5. The sharp increase in rates followed the implementation of the Fair Work Act 2009. The Offshore Hydrocarbons Construction Rate increased 184% in the six years covered by the above graph, increasing from 481% to 663% of Average Weekly Earnings for Australia (assuming offshore weekly earnings were 5 times the daily casual rate).

##### *1.2.3.7 Final Project Outcome*

The actual First Cargo departed on 12 May 2012, 58 months after FID (July 2007), at least 12 months later than realistically expected. The original estimate for the cost of the Pluto Project was $12bn, which became around $15bn, an increase of about 25%.

Even after this delay, the Pluto development duration from field discovery to first product of around 7 years was still fast compared with most other Greenfield LNG projects. For example the first Gorgon field gas was discovered 33 years ago, with first LNG expected in 2014 or 2015.

## 1.3 Causes of poor project performance

There are doubtless more factors that have contributed to the poor track record in Australia of delivering large and complex projects than are set out here. But the following factors are seen by the author to have been significant:

### 1.3.1 Lack of experienced project personnel due to absence of a generation

After the energy and resources sectors enjoyed buoyant conditions in the 1960s, 1970s and the early part of the 1980s, a significant downturn set in after the 1987 stock market crash and the recession of the early 1990s. These subdued conditions lasted right through until the early 2000s, when the rise of China's economy set off the resources and energy boom which lasted until late 2012.

Major companies chose to shut down or sell off their engineering or projects organisations, causing the loss of a generation of project management skills from private companies.

At the same time, there were moves to in some states to privatise government power and energy companies and downsize in others. This resulted in a loss of expertise from those entities and the substantial reduction in availability of apprenticeships.

During the same period, as skills grew in Asia and tariffs were reduced in Australia, it became harder for heavy engineering organisations in Australia to compete and over time, process industry fabricators and equipment manufacturers progressively went out of business or ceased producing locally and converted to becoming importers.

### 1.3.2 Impatience by project proponents to get to market in a rising market

As the demand and prices for Australian commodities soared from around 2003 onwards, suppliers saw unprecedented opportunities to make windfall profits. They developed project proposals as fast as they could and in many cases rushed to commit to projects without sufficient work done to enable thorough development of their scope, design, execution strategy, organisation, project schedule or cost estimate.

Major Australian companies had the desire to maximise their profit-making opportunities by rapidly expanding their capacities, apparently without any longer having the core skills to develop the projects to the required stages of definition to ensure sufficient scope definition and understanding of risk, nor to organise and manage the projects effectively.

After the GFC until 2012, continuation of rising market demand from China and consequent rising commodity prices saved mining project owners from the consequences of schedule and cost overruns because demand still outstripped supply and prices kept rising.

### 1.3.3 Poor understanding by owners of requirements to define and deliver projects

Project proponents have displayed impatience to get to market as described above. But in addition, many of them have not understood what is required to define projects adequately to ensure that their scope, risks, schedules and budgets were adequately defined.

In addition, they lacked understanding of the importance of good quality project personnel in leadership positions or simply could not secure such people, so did not have the capacity to execute projects well. Lack of corporate capabilities in project execution exacerbated the situation.

A clear lesson seems to be not to let operating companies run major projects unless they have well-established, project-focused organisations and methodologies.

#### 1.3.4 Modular Construction increases engineering complexity and stress

The response to high labour costs in Australia is to pre-assemble process plants offshore and bring them to Australia as modules for assembly onsite. But it increases the engineering burden to integrate the structural, equipment, piping, electrical and instrumentation designs and shortens the time available for specification and procurement of equipment and materials to be pre-assembled. It also increases the risks of out-of-sequence work and rework at site.

#### 1.3.5 Consequential descent into chaos of many projects

Without good project leadership or project execution cultures, major and complex projects have a higher probability of reaching the tipping point into chaotic conditions, as described by Hollmann in 2014[viii]. In this state, projects no longer respond linearly to added resources to accelerate or recover progress.

#### 1.3.6 Shortages drive up labour rates and work against improving productivity

The combination of the absence of substantial resource project work opportunities for 15-20 years, reduction in TAFE training and apprenticeships, shutdown of project owner PM-capable groups and divisions and the sudden acceleration of launching of major projects in the 2000s resulted in severe shortages of skilled project capable engineers and trades people. This resulted in chronic under-manning of projects or, just as bad, manning by inexperienced and poorly-skilled personnel.

The use of 457 (Temporary (Long Stay) Business) Visas since 1995 has enabled an influx of overseas trained personnel into Australia and in June 2012 there were 162,000 457 visa holders in the country, including 91,000 workers (balance dependents). While not all 457 visa workers were staffing projects, the fastest growth areas were WA (22.5%) and Queensland (16.8%). Nearly all were private sector employees and nearly 70% were highly paid professionals or managers.[ix]

#### 1.3.7 Demands of workers for unreasonable increases in wages and conditions

As outlined in the Pluto project description, the industrial relations pendulum has swung too far. The combination of the Fair Work Act unduly advantaging unions, industrial courts making determinations favouring unreasonable union demands and high demand for scarce construction resources has produced steeply rising project costs and loss of productivity. Offshore Oil & Gas industry labour costs are now extremely high in comparison with international rates. Australia’s exchange rate remains stubbornly high, exacerbating the situation. Unless there are exceptional circumstances in favour of an Australian project, further investment looks unlikely versus opportunities in lower cost countries, all else being equal.

Incitec Pivot has recently completed a very expensive Ammonium Nitrate project in Moranbah (with plenty to criticise in the way the project was executed). Following on from Moranbah, they are building an Ammonia plant in USA with far lower costs that were highlighted by Incitec Pivot (IP) in May 2014 (The Age)[x]. The A$1bn project, forecast to deliver first product in mid-2016 in Louisiana, would have cost $1.4bn in Australia according to IP. Labour costs are 35% of project costs in Louisiana, but would have been closer to 60% in Australia.
Although most Australians would not consider having the low wages existing in USA and the social problems accompanying them, there must be lessons learned from the unfavourable comparison.

One consequence at the time of writing this paper was an attempt by the Australian Liberal National Party Government to allow foreign maritime workers to work offshore in Australian waters without having to meet the MUA offshore hydrocarbons rates. This may yet succeed.

#### 1.3.8 Work practices promoted and defended by unions and the Labor Party that result in poor productivity

The Fair Work Act mandated access to workplaces by union officials and produced favourable judgments such that construction unions could pressure contractors and project owners into accepting unreasonable increases in wage rates or face lengthy court-protected industrial action.

There has to be a balance between the extremities of Work Choices, which denied workers the right to union representation on the one hand, and legislation that mandates union access to work sites whenever they like and court protection of extended industrial action in support of unreasonable claims. It appears that worker groupthink can win over reason and any concern that future opportunities may be squandered through winning extreme labour rates and conditions. A paper issued by the Reserve Bank in 2011 (Eslake)[xi] highlighted the risks of reduced productivity to the broader community in triggering inflation, as evidenced by an apparently reciprocal relationship between falling productivity and a rising proportion of labour cost to the value of goods and services, illustrated by the following linked charts:

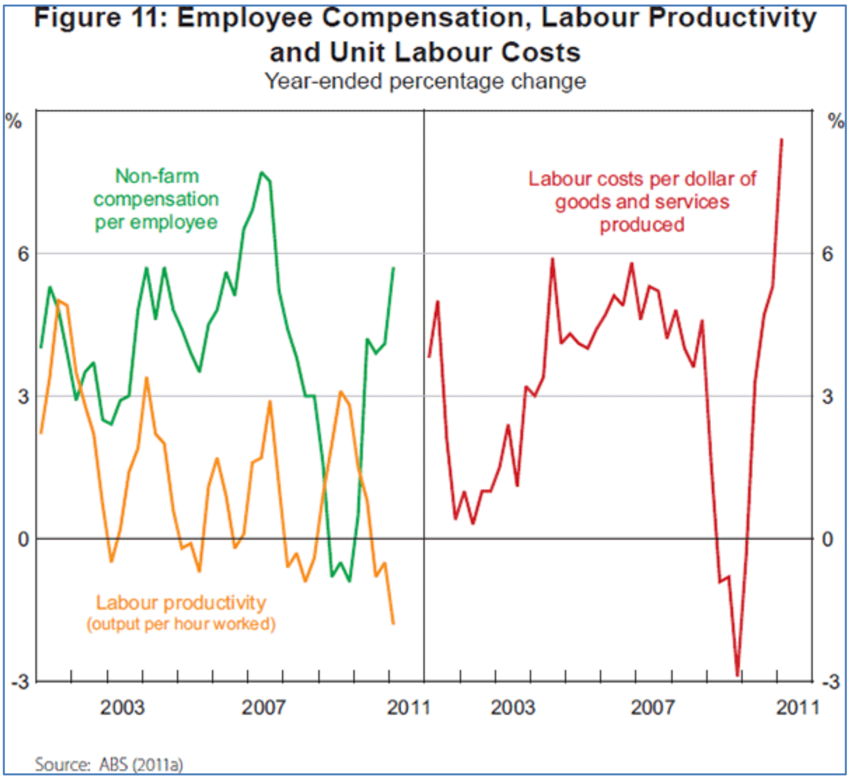


Figure 9: Australian productivity since the GFC versus labour costs and their proportion of goods and services
Source: http://www.rba.gov.au/publications/confs/2011/eslake.html

But in the resources and oil & gas sectors, this situation has already had its impact, as evidenced by:

- the steeply increased Offshore Hydrocarbons award rate and current efforts to utilise foreign workers on rigs and platforms in Australian waters
- the Incitec Pivot comparison between labour costs on their Moranbah Ammonium Nitrate project and their Louisiana Ammonia project

## 2. Changed market conditions

The boom times in Australia between 2003 and 2012 have gone and are unlikely to return for a number of reasons, including the following.

### 2.1 Appreciation of A$

Since it was floated in December 1983, the Australian dollar has fluctuated substantially in its value. However, it has tended to move in concert with the Terms of Trade (defined as the value of a country's exports relative to that of its imports. It is calculated by dividing the value of exports by the value of imports, then multiplying the result by 100. If a country's Terms of Trade (TOT) is less than 100%, there is more capital going out (to buy imports) than there is coming in. A result greater than 100% means the country is accumulating capital (more money is coming in from exports - Investopedia)[xii]. Since 1999, Australia's TOT has risen from around 80 to peak at about 173 in mid-2010, before dropping back to just under 150 in mid-2014. Australia's true exchange rate, represented by its Trade Weighted Index (TWI), reached its minimum of about 77 in 2001 then rose to peak at 140 in 2012 before dropping back to 128 in 2013. This is shown in the graph comparing the two parameters below. This has been the longest rise in Australia's TOT in our history and despite the significant correction in both the TOT and the TWI in the last several years, both remain well above their long-term average. This suggests that while our TOT remains above our TWI, the exchange rate will remain higher than its long term average. Several other factors work to keep the A$ high:

1. Over 20 years of unbroken growth in the Australian economy makes Australia seem like a "safe haven" in which to invest.
2. The severe indebtedness of most of the developed countries and the use of quantitative easing (printing money) by a number of them, with very low or zero exchange rates, making Australia look more attractive as an investment destination.
3. The resources boom has greatly increased the volume of Australian exports which will continue beyond the end of the investment cycle, keeping our Terms of Trade higher.

A high exchange rate means Australia is wealthier and can buy more from overseas, but it also automatically erodes Australia's international competitiveness in terms of labour rates and attractiveness for investment. See Figure 10 below:

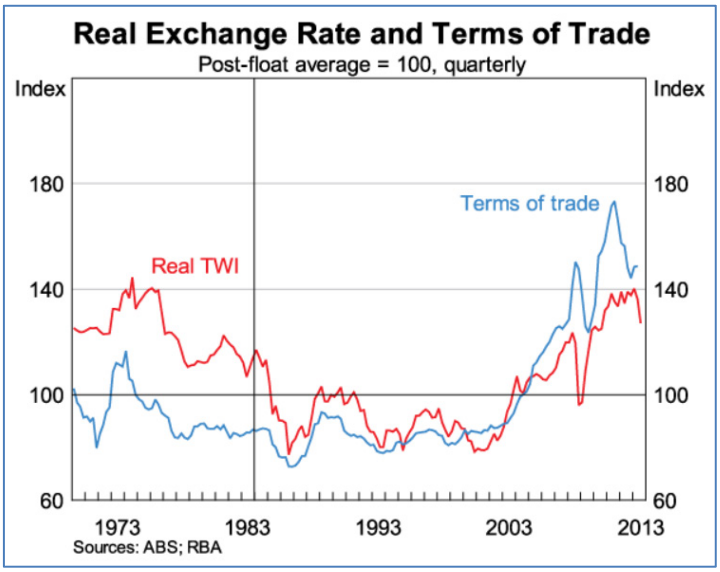


Figure 10: Comparison between Trade Weighted Index and Terms of Trade
Source: http://www.rba.gov.au/speeches/2013/sp-gov-211113.html

## 2.2 Increasing supply & reducing demand reduces commodity prices

### 2.2.1 Cooling of demand in China in 2012 and 2014

In mid-2012, the era of ever-increasing demand in China stopped when supply started to catch up with demand and demand also plateaued and even dipped due to political decisions by the Chinese government to cool economic expansion. This set off a rash of project cancellations, especially in the coal and iron ore mining sectors. Prices and demand subsequently recovered significantly, but prices have again been declining in 2014 for iron ore as supply has risen and demand in China in particular has fallen. In a consistent slide since December 4, 2013, the benchmark iron ore price fell 41% to about US$82/tonne in mid-September 2014.[xiii]

Coal and especially thermal coal prices and projects have not revived noticeably since mid-2012. The decision by China in September 2014 to ban coal with high ash or sulphur for environmental reasons was expected to depress prices and seriously affect Australian coal exports[xiv].

### 2.2.2 Increasing production in 2014

Iron ore producers with higher costs per tonne of included iron have been facing an increasingly bleak future as low cost producers continue to ramp up production. News of BHP Billiton increasing its iron ore production from the Pilbara to a new record in Q2 2014 has been accompanied by news that higher cost producers in China and in Australia are being forced out or having to discount their prices further to maintain production throughput.

# 3. Need for new approaches

It is clear that in the tougher climate for projects in Australia, investment proposals have to be more carefully planned and executed to attract investment. Using similar approaches to what has been done in the past 10-20 years is unlikely to bring higher success rates than previously because of the tougher project conditions described above. Lessons need to be learned and new approaches tried, as set out in this section.

## 3.1 Learn the lessons of the past 20 years

### 3.1.1 Thoroughly define scope

Project owners must settle the scope of projects before Financial Closure to avoid confusing the team or the contractors appointed to deliver the project. The scope must be developed to a sufficient detail for the project planning and estimating to be comprehensive and the risk of growth in quantities or late variations involving design changes is minimised. Failure to follow this requirement is the most cited cause of project overruns.

### 3.1.2 Understand investment risks of the asset as well as the project

Risks to the project should be identified and understood and, whether appropriate, treated and managed. This process should occur in parallel with scope definition. Where it is necessary to bring threats within manageable limits, proactive risk treatments involving significant expenditures should be planned and incorporated in the project budget. Resilience of the project against revenue and opex risks and uncertainties as well as capex and construction schedule risks and uncertainties must be realistically assessed and challenged before FID.

The two mining projects cited in this paper were both hit by severe product price falls not anticipated by their owner when the projects were initiated.

The most effective way to understand project and asset risk and the vulnerability of both project and asset to risk events or structural change in conditions is to model both quantitatively, as set out in the next section.

### 3.1.3 Ensure project specialists assess the investment proposal for the owner

Producing realistic estimates of the time required for completion of a project and the appropriate amount of contingency require skill and experience. Also required is objectivity and avoidance of "groupthink". Consequently, project proponents should ensure that this critical assessment and facilitation work is performed by the right calibre of people and not subjected to undue pressure to produce the "right answers". The answers still have to be produced from models and inputs provided by the project team, but using appropriately skilled and experienced practitioners.

### 3.1.4 Never allow an operating organisation to manage a complex project

The example projects cited earlier include serious lessons against entrusting operating personnel with the responsibility to deliver major and complex projects. They simply do not have the required skills to deal with problems that change every day. Operating companies can safely commission projects, but must entrust the development of the project decision package to experienced practitioners. If necessary, they should bring in independent and capable project auditors to assess how well the project development process is proceeding. They should engage proven project delivery specialists to manage project execution, perhaps using a paid competitive process to select the project management contractor.

### 3.1.5 Rethink project delivery strategy

Traditionally Engineer Procure Construct (EPC) has been used to insulate owners from much of the risk of delivery of major projects. In this model the Contractor undertakes to deliver the project for a lump sum in exchange for charging an amount for accepting the risk. For mega projects, Engineer Procure Construct Management (EPCM) has been the usual approach where risk is too large for the Contractor to accept EPC. Under this model, the EPCM Contractor contributes their project management expertise in exchange for a lump sum fee plus rates for provision of skilled personnel and the Owner accepts procurement and construction contract risk. Penalties and incentives are often applied to the rates to encourage manhour efficiencies.

Experience has shown that these contracting models have not protected the Owner from risk as they expected, but have prevented the Owner from dealing directly with problems and led to rising frustration and deteriorating relationships between Owner and Contractor.

Two approaches that may lead to improved outcomes are suggested:

- Firstly, Early Contractor Involvement (ECI) involves the Owner paying the Contractor to develop the scope and design in collaboration with the Owner until the project is planned and estimated to sufficient detail to agree on levels of time and cost contingencies to “close the books” and for the Contractor to complete the project on a lump sum EPC basis. An independent consultant may be used to facilitate determining the equitable levels of time and cost contingencies to agreed probability levels.
- For projects where the scale is too large or uncertainties cannot be sufficiently defined, an Integrated Project Team approach between the Owner and the Contractor(s) may produce better collaboration and outcomes than the traditional EPCM approach.

#### 3.1.6 Engage specialists with good track record to develop and execute project

Similarly project execution should be awarded to experienced project managers who can provide convincing evidence of recent success in delivering similar projects with the key people nominated for project leadership roles. Project leadership is critical. Do not let the selected project manager organisation substitute “B” or lower team personnel for the key roles in place of well qualified managers and directors who were previously nominated. Given the emphasis on modular construction, proven capabilities to engineer and manage such projects should be emphasised.

#### 3.1.7 Ensure plenty of time contingency for procurement for and completion of modules before shipping

The lesson has been painfully learned in many modularised and offshore platform construction projects in Australia over the last 20 years or more. Shipping incomplete modules or platforms to site is likely to penalise the project quadruple times:

- Each manhour of work not done in the module yard is likely to require at least two manhours on site due to the loss of efficiency, but more if the modules must be completed installed due to hindered access;
- Each manhour on site costs at least double the hourly rate in a SE Asian module yard;
- Offshore work hourly rates are multiples higher than shipyard rates and highly constrained offshore accommodation is likely to reduce productivity further than for onshore work.

#### 3.1.8 Retain and release Unallocated Contingency and if necessary, Management Reserve when needed to guide and motivate the project team

The project schedule and estimate function both as road maps to guide the course of the project and the pattern of its use of capital and also to stretch the project management team to do the best they can do to achieve the shortest duration project execution and the lowest capital cost, commensurate with the required scope, functionality and quality. But if these guides lose their credibility because the team can see that they have no chance of being met, they must be revised to regain those functions. The Owner must do this by rebaselining them and releasing additional contingency funding for the control budget and by re-scheduling the completion milestones so that a practical level of float is restored to each key milestone between the re-forecast date and the revised and delayed target date.

Such rebaselining should not be done more than once in a project, but in projects running for three years or more, rebaselining twice could be required. Management Reserve is funding beyond the sanctioned limit that the project Owner may be called upon to contribute in exceptional circumstances.

As an example, Exxon Mobil’s PNG LNG Project First Cargo was achieved in May 2014, which was claimed in the media to be early. But when the project was sanctioned in December 2009, First Cargo was forecast for December 2013, 48 months later. A Management Reserve of 10 extra months was allocated to give a First Cargo including Management Reserve of October 2014 (58 months). So May 2014 was late against the sanctioned project duration and used up half the Management reserve (53 months). In addition the originally sanctioned cost was just over US$16bn, so the actual completion cost of US$19bn was 18% over original budget. The time and cost performance of PNG LNG is regarded as a success because of the challenges of project work in PNG and the way the project performance was presented publicly.

#### 3.1.9 Develop fair but firm industrial relations laws

A review needs to be made by a balanced and rational body to consider evidence of the effects on recent projects of the current Fair Work Act and any other industrial relations requirements that significantly impact on Australia's construction projects productivity and competitiveness. This body should recommend changes to be legislated to bring a better and more flexible equilibrium back to industrial relations laws applicable to construction projects or Australia is likely to face a longer period of low resource projects activity.

#### 3.1.10 Drive for higher productivity

In April 2014, the Productivity Commission stated that Australia's productivity had lagged behind that of comparable countries for more than a decade and warned that record Terms of Trade could no longer support income growth.[xv] The role of Productivity is not clear-cut, falling when large-scale investment in facilities is not yet producing output (such as when mining and oil & gas facilities are being built), or project owners are prepared to invest inefficiently to get into the market in boom conditions. But in the aftermath of the surge in investment, Australia needs productivity to improve. Australian resource projects, competing against global investment alternatives, must be built on improved productivity. Innovative ways to construct such projects are required with cooperation between workers and project owners in their common interests. Woodside is taking the initiative in this by promoting industry techniques such as Lean Manufacturing and Building Information Modelling (BIM), specifically to improve the productivity of constructing oil & gas facilities and has appointed a manager to promote such techniques. In 2012 a Recommended Practice published by Engineers Australia arising from this work was published specifically relating to onshore LNG plant construction (Engineers Australia WA Division)[xvi].

#### 3.1.11 Recruit well and thoroughly train the team to operate the asset

The team to operate the asset being built by the project must also be capable and be led by experienced practitioners who understand how to lead and direct a team to operate a complex process plant, preferably similar to the one being built. Leadership is important. Corporate procedures are a good start, but they must be complemented by people who understand well how to implement procedures and also develop teamwork and collaboration.

## 3.2 Use a new technique for holistic assessment of the project and asset investment

Even if completely adopted, the preceding lessons are not enough. Project proponents need to develop the ability to identify and define the projects and accompanying asset investment proposals that will have the resilience to succeed in a comprehensive range of project execution and asset operating conditions. The proponents also need the ability to identify and rank the key risk drivers so that they can optimise the risk profile of the project and asset investment proposition before submitting the proposition to the Financial Closure process.

This section describes a recently developed quantitative risk analysis methodology and tool applicable to the full project execution cycle from Pre-FID through Project Startup and operational life cycle to Asset Closure and Remediation. We call it Integrated Costs, Schedule and Revenue Risk Analysis (IRRA). On its own it is not sufficient to ensure success, but if thorough project and asset scope definition and assessment are inputs to its use, success rates of investment proposals using it should improve materially.

#### 3.2.1 Based on Integrated Cost & Schedule Risk Analysis of projects

In recent years, with the improvement of available Monte Carlo simulation software and the hardware to run it, the capacity to perform true integrated cost & schedule risk analysis on major and even mega projects using the integrated master control schedule normally used by the project team to track the project's progress at a level of detail that reveals meaningful critical paths.

By overlaying this relatively detailed schedule with the project estimate, broken into appropriately apportioned fixed (time independent) and variable (time dependent) costs, linking those costs to the activities funded by those costs, inputting probability distributions for all costs and durations that are uncertain and mapping in risk events from the risk register with significant probabilistic schedule and cost impacts, a realistic model of the project and its costs can be simulated. In addition, identification of the duration and cost uncertainties that drive the project duration and cost allows the opportunity to understand and optimise the riskiness of the project in both dimensions.

This Integrated Cost & Schedule Risk Analysis (IRA) methodology has been used successfully on projects ranging from a few million dollars to more than $15 billion dollars (Cropley, 2014)[xvii].

#### 3.2.2 Extended to whole of life of the asset

While IRA is very effective in assessing the range of possible time and cost outcomes of a project, enables identification of appropriate levels of time and cost contingency and facilitates effective project risk optimisation, it omits consideration of major parts of the uncertainty of the investment value proposition, which often determine whether investment proceeds or is abandoned – the uncertainties and risk events relating to operational costs of the asset and the revenue flowing from it (or, occasionally, the cost savings, if the purpose of the asset is to reduce operating costs, such as a major piece of public infrastructure). To do this, it is necessary to extend the project IRA model beyond startup to cover the entire economic life of the asset (or at least the period of economic analysis), including, if applicable, asset closure and remediation.

#### 3.2.3 Incorporate operating uncertainties and risks

Such IRRA modeling must include operational reliability and availability and incorporate major shutdowns, their timings, intervals and costs and corresponding interruptions to revenue generation.

Operational uncertainty elements to be incorporated in the modeling include:

- Changing production / operating costs and efficiencies;
- Occurrence of maintenance shutdowns; and
- Changes in regulations and compliance costs.

Operational Risk factors to be modelled could include:

- Operating cost inputs such as labour, utilities and raw materials/feedstock;
- Market conditions for various inputs including
    - Maintenance costs;
    - Shipping of product and raw materials; and
    - Cost of borrowing money / interest rates.

Risk events to be modelled affecting operating conditions could include:

- Threat of extended industrial dispute by operational workforce; and
- Threat of more stringent environmental regulations increasing operating and maintenance costs.

#### 3.2.4 Incorporate revenue uncertainties and risks

Revenue uncertainty elements to be incorporated in the modeling include:

- Fluctuations in market pricing affecting revenue, whether cyclical or structural;

Risk events to be modelled affecting revenue could include:

- Threat or opportunity of major change in product pricing beyond normal cyclical variation;
- Opportunities for premium pricing of product sold on the spot market rather through long term contract commitments;

#### 3.2.5 Include financing uncertainties

Financing risks and uncertainties could include:

- Uncertainty of rates of interest to be charged through the project and asset lifecycles;
- Risk that project finance market conditions fluctuations may result in increased interest rates; and
- Risks of changes to government taxes, charges and subsidies.

#### 3.2.6 Produce probabilistic cash flows, NPVs & IRRs from FID to asset closure

By modelling operating and revenue uncertainty and risks for the whole project and asset life cycle from conception to asset closure and remediation, probabilistic cash flow curves can be produced and from these, probabilistic NPV and IRR distributions.

#### 3.2.7 Test sensitivities of Project/Asset RoI to wide range of changes in assumptions

With such a comprehensive IRRA model, its resilience and ability to withstand various sensitivity "tests", while still producing an acceptable return on investment can be assessed.

#### 3.2.8 Produce probabilistic balance between investment success and failure

Through the above life cycle probabilistic cash flows, NPVs and IRRs, the probabilities at which the project and asset change from being healthily profitable to breaking even and then to making an unacceptable loss can be explored.

Because all this can be done on the one model integrating all development and execution costs and risks through operation and revenue uncertainties and costs, and all drivers of profitability explored and sensitivities assessed, for the first time, such integrated analysis provides an unprecedented opportunity to improve understanding of a project before financial commitment is made.

## 3.3 Illustrated by use of demonstration FLNG project

This IRRA approach has been explored previously using a mining and minerals processing example (Cropley, 2013)[xviii]. For this paper a conceptual Floating LNG project and asset is being used. Several factors make this particularly appropriate for Australia at this time:

- There are several such projects currently being studied in Perth or, in the case of Shell's Prelude project, in execution, with the Prelude FLNG vessel having been launched in Korea in December 2013 and currently being fitted out with the LNG train moored at a wharf under shipyard conditions.
- The FLNG project is conceptually very appropriate to study using IRRA methodology because it incorporates the approach of being able to take the main revenue producing facility – the FLNG vessel – elsewhere, after exhausting the gas field assets on which its design and construction have been based, in a relatively short time, and redeploying it elsewhere.
- The project economics are likely to be sensitive to the residual value of the FLNG vessel and the ease with which it can be reconfigured and redeployed to a different field, although that sensitivity will be reduced as the DCF rate is increased and the life of the field(s) supplying the FLNG vessel increases.
- Another trade-off appropriate to investigate by IRRA modelling is between increased capital expenditure (capex) on a more efficient and reliable LNG process that produces higher revenue per unit time and lower operating expenditure (opex); versus lower capex for a simpler LNG train process but higher opex and lower revenue per unit time. The cost of project finance and the DCF rates chosen will influence the relative attractiveness of these options.
- Additionally, the FLNG project approach is similar to the already established Floating Production, Storage and Offtake (FPSO) Vessel concept for smaller offshore oil fields, already used widely including in Australian waters. The FPSO concept is simpler and substantially less expensive.

#### 3.3.1 Features of the FLNG Conceptual IRRA Model

The FLNG project and asset schedule starts from the Concept Phase and progresses through Pre-FEED, FEED, Financial Closure and Execution Phases of the project, to First Cargo. The Operations phase is assumed to continue for 25 years, with maintenance of the FLNG vessel stopping production every 5 years. The first 15 years are shown in the summary view of the schedule below:

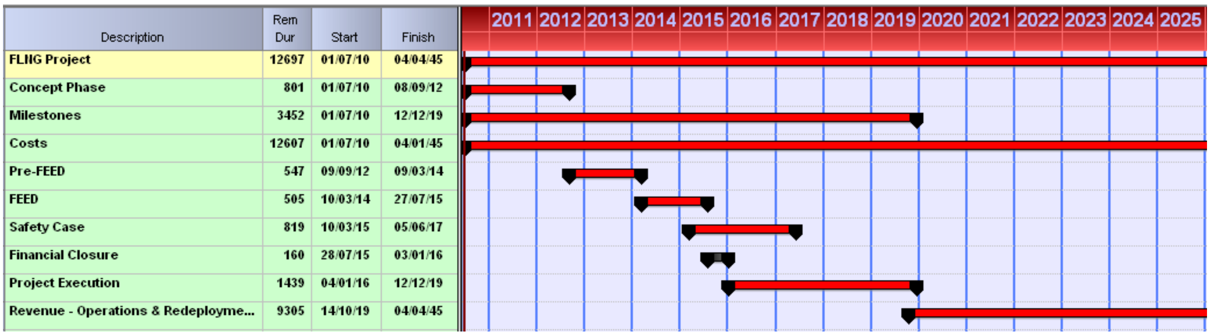


Figure 11: Section of FLNG Project & Asset Schedule for IRRA Modelling

About 200 activities were used to describe the project and operation of the assets over the 5 years leading to FID, the four years of project execution and the 25 years of operation followed by field closure and remediation with FLNG Vessel notional sale to another project (a "balloon payment") and transfer for refit and reconfiguration. The tasks leading up to First Cargo were subject to duration uncertainty ranging and the maintenance shutdowns of the FLNG vessel every 5 years were also duration ranged. Notional fixed and variable costs were assigned to the various phases of the project and subject to ranging by duration (Variable costs) and cost distributions (Fixed costs).

LNG revenue assigned to fixed monthly production blocks was ranged to represent uncertainty and 6-monthly maintenance tasks every 5 years (subject to duration uncertainty ranging) interrupted the production revenue stream. Notional Opex costs were assigned for maintenance, operations and remediation on field closure.

### 3.3.2 Outputs from FLNG Conceptual IRRA Model

The following probabilistic cash flow was produced for the project and asset – see Figure 12. Note the assumed balloon payment for the FLNG Vessel at the end of the cash flows.

The three curves shown are P10 (top curve), Pmean and P90 (bottom curve). The DCF discount rates are built into the histogram values. The 5-yearly maintenance shutdown costs and breaks in revenue cause the “ripples” in the histogram bars and the cumulative curves.

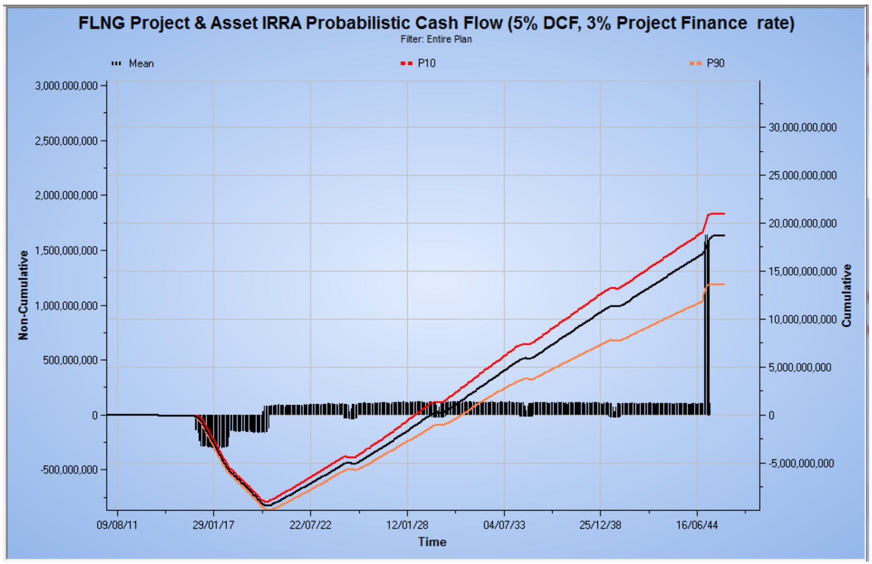


Figure 12: FLNG Project & Asset Probabilistic Cash Flow from IRRA Modelling

The analysis enables probabilistic Net Present Values (NPVs) and Internal Rates of Return (IRRs) to be produced. In the IRRA modelling, we included a 10% probability risk that there would be an LNG price drop of around 20% (10% minimum, 30% maximum) that would affect the LNG revenue from year 6 onwards. This causes the bimodal distribution in the Probabilistic NPV analysis shown below:

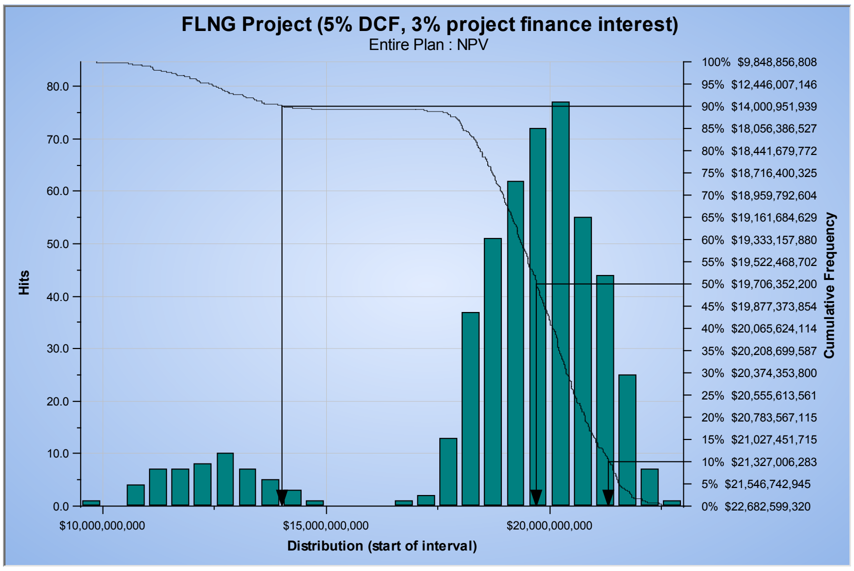


Figure 13: FLNG Project & Asset Probabilistic NPV Distribution from IRRA modelling

In addition to these financial analyses which take into account revenue, capex and opex uncertainties and risks, it is possible to produce the usual cost and schedule probability distributions for First Cargo and any intermediate milestones and key subsidiary costs, along with the schedule and cost drivers.

#### 3.3.3 Benefits of IRRA Modeling

This integrated approach enables the evaluation of a full range of uncertainties and risks that may affect capital cost, development or construction timing, startup and operating costs and conditions or revenue.

The project and the revenue generated from the resultant asset may be sensitive to weather uncertainties and fluctuations, market conditions such as changes in supply and demand balances or regulatory changes that may change operating costs or product pricing.

Once the time/cost/revenue model developed meets stakeholder needs, it can be used to model any uncertainty or risk event that has incremental or sudden effects on timing or costs, in any phase of the project and asset. Such an integrated model enables sensitivity analyses for all kinds of combinations of conditions that may be envisaged as possible.

The model can also be used to model different combinations of risk treatments to optimise the treated risks and the overall project for best possible outcomes and cost-effectiveness.

Optimisation can extend to modelling operational reliability and availability, taxation and depreciation, to produce the most realistic and informative analyses.

Thus the IRRA model can integrate project estimating, planning and risk management together with operations and maintenance modelling and economic analysis.

# 4. Conclusions and Recommendations

## 4.1 Australia’s relative advantages have largely disappeared

The boom conditions for the Australian Resources and Energy sectors are unlikely to recur in the foreseeable future due to the reducing rate of growth of China and the maturing nature of its growth away from raw materials. In addition, alternative sources of supply of commodities at more attractive or comparable prices are also changing the balance away from sellers toward buyers and in any case, away from Australia.

Australia’s significantly and persistently higher currency value and substantial rises in labour rates, combined with falls in productivity have made Australia’s construction costs quite uncompetitive with much of the rest of the world. Australians have to change this situation to enable the resumption of developing opportunities for increasing prosperity and well-being in this globally competitive world.

## 4.2 Need to reduce risk to access Superannuation Funds

This also applies to infrastructure megaprojects, even though they may not be competing directly for export markets. The higher the cost and worse the performance, the less likely it is that governments or our own superannuation funds will fund construction of such projects. It is crystal clear that the riskiness of construction of infrastructure projects scares away the plentiful superannuation funds available in Australia (exceeding $1.8 trillion at 31Mar14) (ASFA, 2014)[xix], but such funds are very eager to own infrastructure once it is built and revenue streams are established. Finding ways to hedge the risk to such funds could unlock plentiful funds for major and mega projects in Australia, but this will increase pressure on project proponents to meet project time, cost and asset return targets.

## 4.3 Need for training for senior project managers and directors

Too many megaprojects in Australia have run into trouble due poor choices made during the project development phase and to poor project management during execution. Much of this has been due to a totally inadequate supply of skilled and experienced project management personnel, particularly at senior levels. The setting up of the John Grill Centre for Project Leadership at The University of Sydney in 2012 to develop project managers and project directors capable of leading megaprojects effectively is a most welcome initiative, but there is a need for industry-wide identification of potential project leaders and providing them with accelerated learning opportunities.

## 4.4 Need for better project management skills

Development of highly capable practitioners of the full range of project knowledge areas is also important. Developing such capabilities requires absorption of theory and practice. Possible options for acquisition of project management theory are:

- Academic project management courses such as Diplomas and Masters degrees, usually one year full time or longer on a part-time basis;
- Accreditation through professional bodies such as the Australian Institute of Project Management (AIPM), the US-based Project Management Institute (PMI) or discipline specialist bodies such as the Association for Advancement of Cost Engineering International (AACEI), all of which have educational and evaluation programs leading to certification.

Both options need to be closely tied to best practice project management with emphasis on practical experience, to ensure that theory is closely tied to practice and is not just certifying the ability of someone to absorb the vocabulary of project management without understanding the practice.

The challenge is to provide suitable project management experience. While we learn from mistakes, seeing best practice in action, grounded on well-expressed project management procedures, is clearly preferable.

## 4.5 Need for Corporate Project Management Memory

The best way to ensure good training and good practice for the future is to provide ongoing "corporate memory" in organisations that initiate projects, by retaining core capabilities in all the disciplines of project management, built on documented project development and execution procedures and processes. Such procedures and processes must include absorbing and incorporating Lessons Learned from previous projects into future projects. This will not happen unless project executing organisations set aside adequate budget provisions for Project Closure and ensure the project team members who learned the lessons write up the lessons and deliver them to the core project management team and, where necessary, to senior management. "Those who cannot remember the past are condemned to repeat it." (Santayana, 1906)[xx]

## 4.6 Need for Balance in Industrial Relations Law

Australian megaprojects will have significantly improved likelihood of completion within their target time and cost targets if industrial relations laws are balanced between the rights of workers and project owners. Unions should have the right to represent their members, but not the right to blackmail project owners and contractors to grant excessive wages and conditions.

The consequences of getting too out of balance in either direction are unpleasant. Conditions of great shortages of skilled and specialised workers breed the latter out-of-balance situation and the ultimate consequence of work no longer being available, such as with attempts to exclude MUA members from working offshore, or the cessation of construction of onshore LNG plants. Taking away workers' rights to collective bargaining leads to electoral retribution as seen with the Work Choices election of 2007.

## 4.7 Plan Projects and Investments thoroughly before Execution

Thorough development of project and asset investment proposals is a crucial prerequisite for successful execution of projects. Yet this has been lacking in a remarkably high proportion of large and mega projects in Australia in the last 20 years, as evidenced from the assessments quoted at the start of this paper. Several recommendations arise from this:

- Proper definition of the scope and complexity, costs and returns of projects and their associated assets requires specialised expertise and experience. This should be entrusted to core teams to manage which have enough experience and documented processes to ensure it is done well and that the foreseeable risks and sensitivities have been explored as thoroughly as required to produce a resilient proposal.
- Where such skills do not exist in an organisation proposing the investment, the organisation must create them by recruiting a team with the required combination of skills and experience, or bring in a team capable of doing the work. They should obtain expert "cold eyes" advice as to whether the team is adequate and whether any gaps need to be plugged.
- They should ensure they have the analytical tools and skills to verify that the project and asset investment proposal has been properly developed and that risk has been optimised, before

proceeding to Financial Investment Decision (FID). This paper has put forward a methodology – Integrated Costs, Schedule and Revenue Risk Analysis (IRRA) – which will perform this function effectively in the period leading up to FID. Because it enables an holistic analysis of the entire project and operation of the asset including revenue uncertainty, it provides for the first time, an integrated approach to drawing together all the strands of project definition, design, procurement, construction, operation and revenue generation and their uncertainties and risks. This enables the evaluation of the investment proposal and its sensitivity to a wide range of changes to inputs and occurrence of risk events. The probabilistic balance of investment risk between making good returns and making unacceptable losses can thus be explored and defined and the risk drivers optimised to improve that balance where possible.

- Following the optimising of project risk, but before proceeding to FID, project benchmarking should be performed, to ensure that the project is within acceptable parameters versus best practice standards globally. Major identified deficiencies should be rectified before proceeding to FID.

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