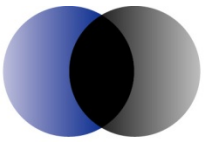
# Nation Builder

How the North West Shelf Project has driven economic transformation in Australia

Prepared for the North West Shelf Venture participants:
BHP Billiton Petroleum (North West Shelf) Pty Ltd
BP Developments Australia Pty Ltd
Chevron Australia Pty Ltd
Japan Australia LNG (MIMI) Pty Ltd
Shell Development (Australia) Pty Ltd
Woodside Energy Ltd (Operator)

**October 2009**



ACIL Tasman
Economics Policy Strategy

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# Key points

The six participants in the North West Shelf (NWS) Project are BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, Shell Development (Australia) Pty Ltd and the Operator, Woodside Energy Ltd.

The NWS Project is one of the largest resource developments undertaken in Australia, involving construction expenditures of more than $27 billion:

Construction expenditures of more than $50 billion would be required to construct the NWS Project facilities today.

This pioneering project has changed the face of Australia's upstream energy industry and helped to establish Australia's reputation as an international supplier of LNG.

The NWS Project continues to contribute to Australia's economic prosperity. Over the period 1989 to 2009 the NWS LNG operation has generated (all in real 2008-09 Australian dollars):

- export revenues approaching $60 billion
- increased Gross Domestic Product (GDP) for Australia totalling more than $70 billion, with increased Gross State Product (GSP) for Western Australia totalling more than $90 billion
  - this represents a boost to annual GDP of around 0.7 per cent and a boost to GSP of around 5 per cent
- increased consumption by Australian households totalling more than $40 billion
  - with the commissioning of Train 5, annual contributions will grow to more than $4 billion per annum
  - and more than 80 per cent of this increased consumption is estimated to accrue to Western Australia
- total annual taxation benefits for the Commonwealth, including royalties, estimated to be approaching $4 billion, and for the Western Australian State and local governments, to be around $0.9 billion per annum
- a mix of increased real wages and substantial additional employment.

The NWS Venture's Karratha Gas Plant is currently Western Australia's largest producer of domestic gas, accounting for about 65 per cent of total State production:

- the majority of natural gas is utilised for industrial purposes and power generation, underpinning Western Australia's competitiveness and exports

- the direct and indirect contribution to Western Australia's GSP from the domestic gas operations alone is estimated at around $750 million.

The NWS Venture participants continue to invest in developing infrastructure – with more investment in hand or planned for the near future, including:

- $5 billion for the North Rankin Redevelopment Project, and
- $1.8 billion for the redevelopment the NWS Cossack, Wanaea, Lambert and Hermes oil field production facilities.

The development of the oil and gas industry has helped drive the economic and social development of north west Western Australia

- Karratha's economy is significantly supported by the oil and gas sector
- the NWS Venture participant's investments in roads, housing, health services and education in Karratha and the Shire of Roebourne now exceed $300 million.

The NWS Project has driven the application of leading technologies in Western Australia, and the subsequent development of a thriving local oil and gas sector

- this has led to the emergence of a petroleum services hub in Perth
- in addition, many oil and gas services providers now have moved on from their initial role in supplying the NWS Project, to expand and diversify into new markets and technologies, both here and overseas
- this diversification and growth is driving a broadening and deepening of the Western Australian economy, leading to permanent structural change
- the skills and technologies developed through the execution of the NWS Project are underpinning new and planned oil and gas developments.

# Executive summary

This report assesses the economic and social contribution of the North West Shelf Venture (NWSV) resource development to the nation, to Western Australia, and to the Pilbara region. It includes both 'traditional' economic measures and discussion of the broader impacts – the latter focussing on the industry development and structural change in Western Australia that the NWS Project has stimulated and facilitated.

## NWS Venture operations

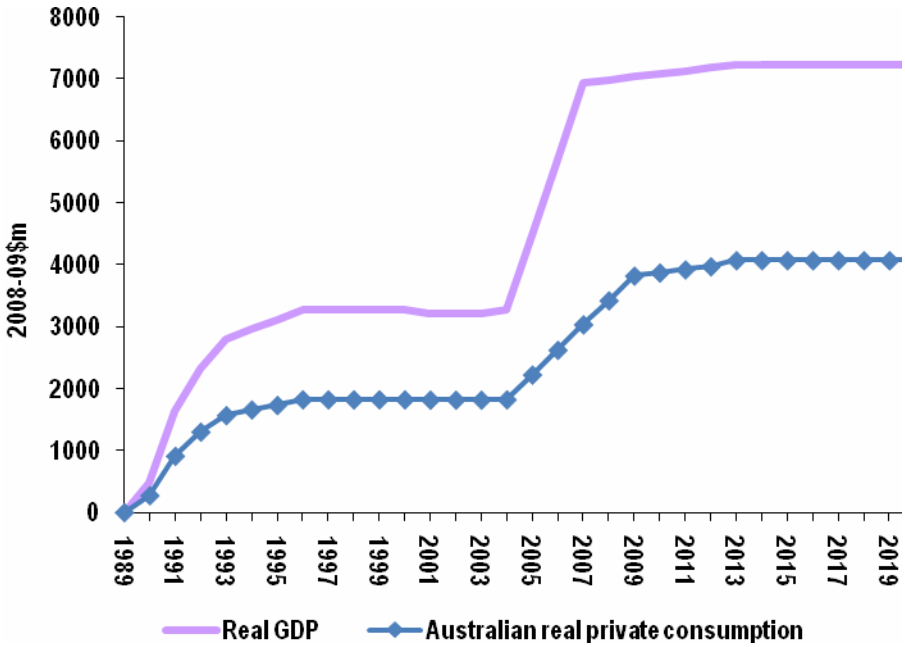
The NWS Project is one of the largest resource projects ever undertaken in Australia, involving construction expenditures of $27 billion. Construction expenditures of more than $50 billion would be required if the facility were to be built today.

This pioneering project has changed the face of Australia's upstream energy industry and helped to establish Australia's international reputation as a safe and reliable supplier of LNG.

The NWS Project continues to contribute to Australia's economic prosperity. It has generated (all in real 2008-09 Australian dollars):

- export revenues approaching $60 billion to date
- increased Gross Domestic Product (GDP) for Australia totalling more than $70 billion over the period 1989 to 2009
  - annual contributions to Australia's GDP have grown to around $7 billion per annum, which will be maintained through the period 2010 to 2019 (Figure ES1)
  - this represents a boost to annual GDP of around 0.7 per cent
- increased Gross State Product (GSP) for Western Australia approaching $90 billion over the period 1989 to 2009
  - annual contributions to Western Australia's GSP have grown to approach $8 billion per annum, which will be maintained through the period 2010 to 2019
  - this represents a boost to annual GSP of around 5 per cent
- increased consumption by Australian households totalling more than $40 billion over the period 1989 to 2009
  - with annual contributions estimated to grow to more than $4 billion per annum in the period 2010 to 2019
  - and more than 80 per cent of this increased consumption is estimated to accrue to Western Australia

Figure ES1 **NWS Project total GDP and private consumption impacts - Australia**




*Source*: ACIL Tasman analysis

- total petroleum royalty revenues of more than $10 billion over the period 1989 to 2009 – with two thirds, or just under $7 billion, flowing to Western Australia
  - annual royalty payments by the NWS Project now exceed $1.2 billion per annum
- company and other taxation impacts for Phases 4 and 5 are estimated to be boosting Commonwealth revenues by up to $1.6 billion per annum (assuming a mix of wages increases and flow-on employment impacts), and Western Australian State and local government revenues by $40 million
  - given relative sizes, we estimate that Phases 1, 2 and 3 will be delivering similar revenues
- overall then, with royalty payments added in, the total taxation benefit for the Commonwealth from the NWSV is estimated to be approaching $4 billion per annum, and for Western Australian State and local governments, to be around $0.9 billion
- a mix of increased real wages and additional employment.

## NWS Project domestic gas

The NWS Project domestic gas operations delivering significant benefits in their own right:

- using input-output multipliers, the direct and indirect flow-on contribution to Western Australia's Gross State Product (GSP) from the NWS Project's domestic gas supply operations is estimated to be around $750 million
  - downstream users of the domestic gas will be contributing significant further activity
- the NWS Project's domestic gas operation contributes directly and indirectly to over 900 jobs in Western Australia.
  - again, downstream users of domestic gas will be providing significant additional employment.

## Future investment by NWSV

The NWS Venture participants continue to invest in developing infrastructure – with more investment in hand or planned for the near future, including:

- $5 billion for the North Rankin Redevelopment Project, and
- $1.8 billion for the redevelopment the NWS Cossack, Wanaea, Lambert and Hermes oil field production facilities.

## Contribution of NWSV Project domestic gas to Western Australia

Prior to the development of the NWS Venture's Karratha Gas Plant in 1984, natural gas consumption in Western Australia was only about five per cent of present levels. Gas supply was limited to relatively small volumes available from the Perth Basin and delivered to the Perth area through the Parmelia Pipeline.

However, the opening up of the North West Shelf fields in 1984, through the NWSV development and the associated completion of the Dampier to Bunbury Natural Gas Pipeline, allowed the Western Australian domestic gas market to grow rapidly. Domestic gas demand in Western Australia has expanded by 7 per cent in compound average growth terms since that time, to exceed 350 PJ/annum in 2008.

The NWS Venture's Karratha Gas Plant is now Western Australia's largest producer of domestic gas, accounting for about 65 per cent of total State production.

The vast majority of natural gas in Western Australia is utilised for industrial purposes and power generation. Five large customers, Alcoa, Alinta, BHP Billiton, Burrup Fertilisers and Verve Energy, account for 90 per cent of gas consumption in Western Australia. Power generation, alumina refining, and resource processing and manufacturing in the South West accounts for over 80 per cent of existing gas demand.

The Western Australian gas market is characterised by:

- a high proportion of direct gas sales in the industrial sector, predominantly for minerals processing and basic chemicals – for example, the alumina refining operations in Western Australia are among the lowest cost operations in the world, which has been facilitated by the use of NWS gas
- a high level of use of gas in power generation
- a relatively small utility (commercial/residential) sector – reflecting the State's small population.

## Regional development

The NWSV has committed to considerable investment in infrastructure in the North-West, leading to significant regional development outcomes. The NWS Venture participants' investments in roads, housing, health services and education in Karratha and the Shire of Roebourne now exceed $300 million.

The development of the oil and gas industry has helped drive the rapid economic and social development of Karratha. Based on input-output analysis, in 2005-06 the Gross Regional Product (GRP) at factor cost of Karratha was estimated to be $13.2 billion. Of this, the resource industry contributed over 95 per cent of Karratha's economy, with the majority contribution to this arising from the oil and gas sector.

## Oil and gas industry development

The NWS Project required the application of leading technologies which had previously not been available in Australia. Consequently, there was a need for technology transfer from overseas, as well as technological innovation to adapt that technology to Australia. This has underpinned the subsequent development of a thriving oil and gas sector in Western Australia, and the emergence of a petroleum services hub in Perth.

Technology transfer led to the NWS Project operator, Woodside, and the local sub-contractor network, developing considerable expertise in LNG and domestic gas plant construction and maintenance, and in associated technologies. At the same time, the local industry has become adept in developing remote deepwater fields, understanding meteorological and

oceanographic conditions, and in applying related exploration and reservoir characterisation methods. The technologies and expertise developed through experience with the NWS Project are benefitting new and planned oil and gas projects.

This had a significant impact on the economic structure of the Western Australian economy. Many oil and gas services providers have moved on from their initial role in supplying the NWSV, to expand and diversify into new markets, both in Australia and overseas. This diversification and growth is driving a broadening and deepening of the Western Australian economy, leading to permanent structural change for the economy.

# 1 Introduction

ACIL Tasman was engaged by the North West Shelf Venture (NWSV) participating companies to assess the economic and social contribution of the NWS Project to the nation, to Western Australia, and to the Pilbara region. The objective is to increase understanding of the scale of the NWS Project and its significant contribution to the development of the oil and gas industries in Australia.

The NWS Project was groundbreaking in its concept and execution. It involved offshore development on a scale not undertaken before in Western Australia. It has delivered domestic gas for 25 years, fuelling expansion of the minerals industry and diversifying electricity generation. It was Australia's first LNG project, developing the market and leading the way for more major LNG developments that are now underway.

This assessment includes both 'traditional' quantitative economic measures and discussion of the broader impacts. The benefits have included increases in GDP, employment and government revenues, as well as regional development in the Pilbara. The NWSV has facilitated industry development and economic change in Western Australia.

The study covers both the periodic impacts of construction of each phase of the NWS Project and the impacts of the ongoing Project operation out to 2020.

## 1.1 This report

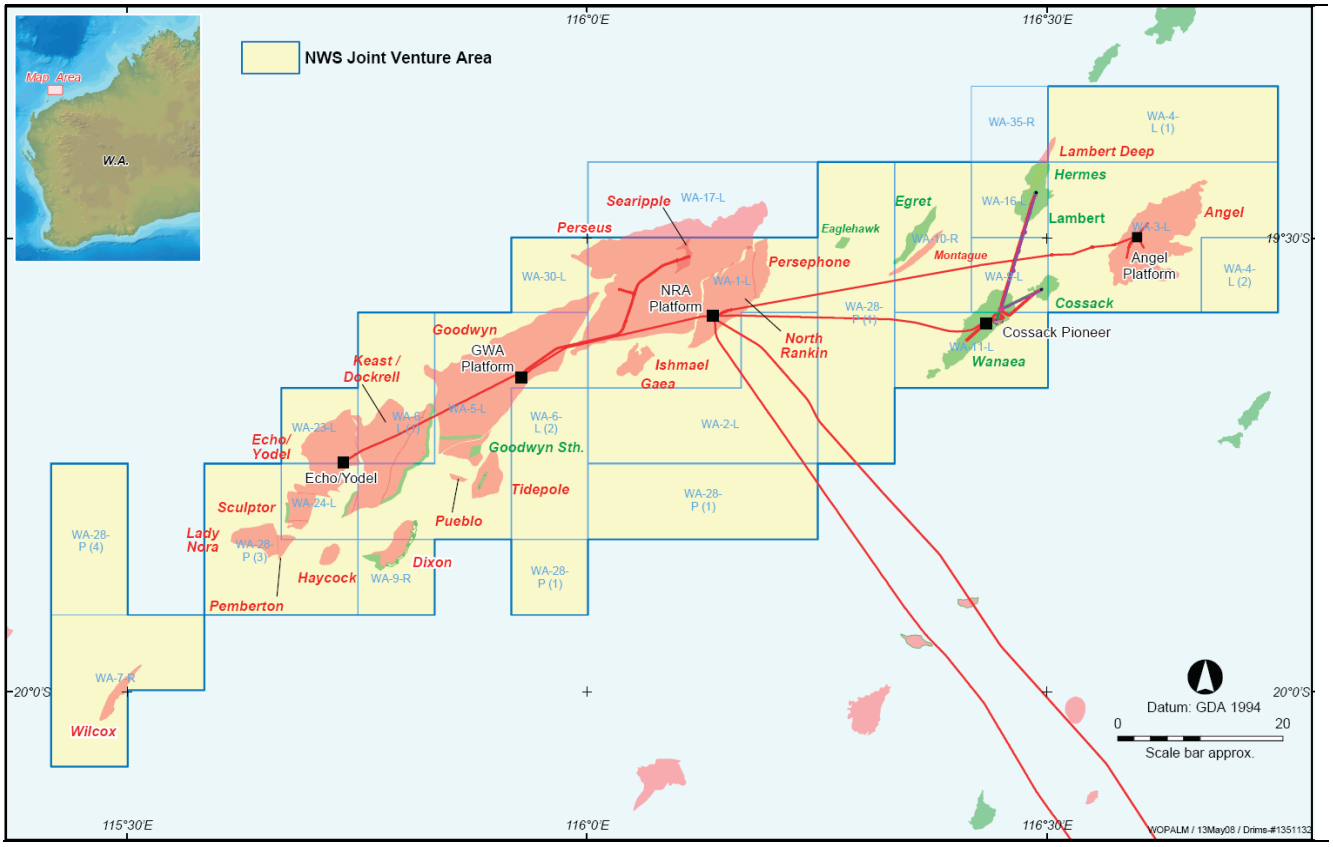
In what follows:

- Chapter 2 outlines the key features of the NWS Project
- Chapter 3 assesses the economic impacts of the NWS LNG operations
- Chapter 4 outlines the contribution of NWS domestic gas to Western Australia
- Chapter 5 evaluates the broader economic and social developments that have been facilitated by the NWS Project.

# 2 The North West Shelf Venture

The NWS Project is underpinned by massive gas and oil fields located approximately 125 km north-west of Dampier in the Carnarvon Basin in water depths ranging between 125 and 131 metres. The Perseus field is an important long-term supplier of gas into the NWS Project and represents about one third of its gas resources. Other producing fields include North Rankin, Goodwyn, Angel, Searipple, Echo/Yodel, Cossack, Wanaea, Lambert and Hermes.

Figure 1 **NWSV fields**

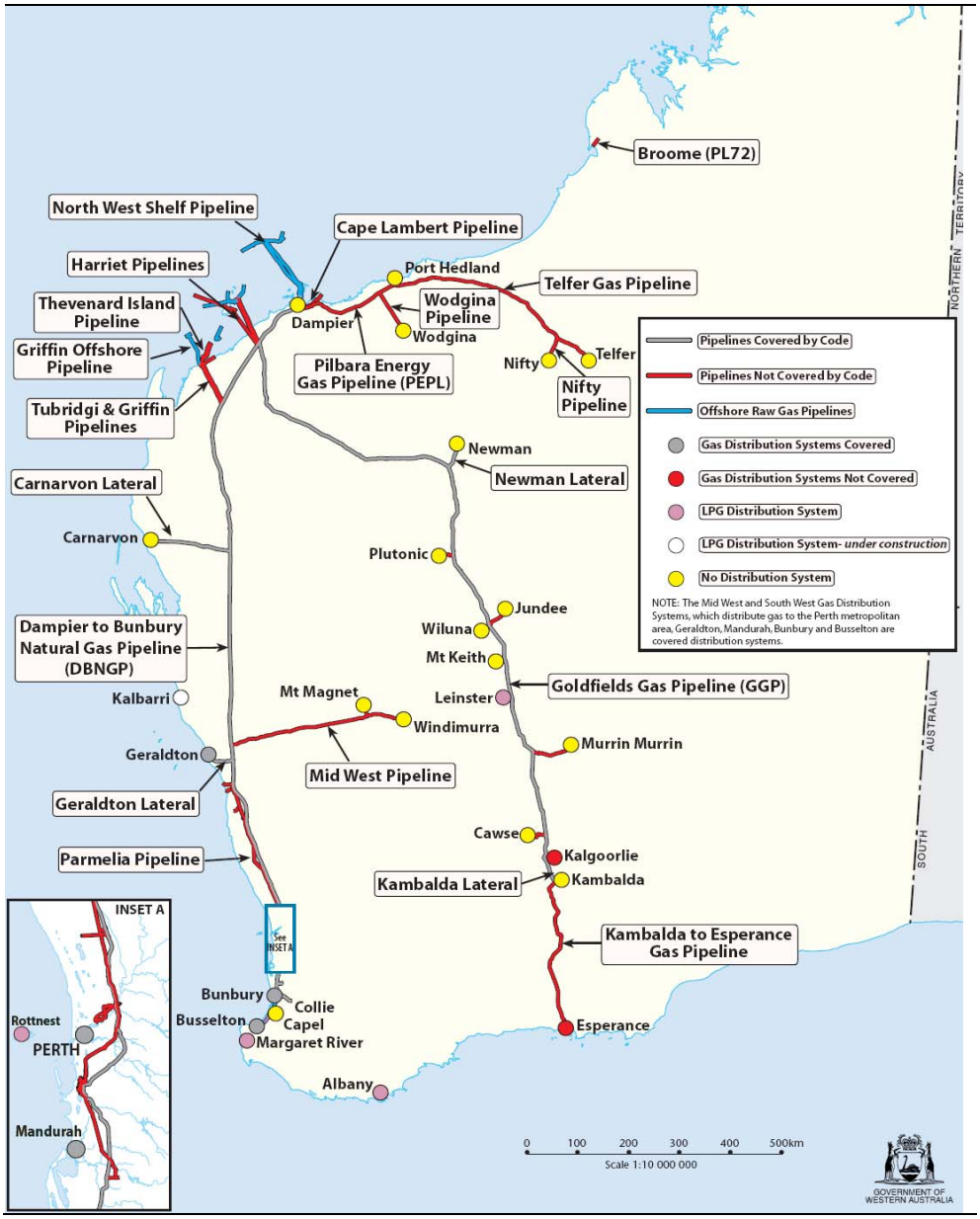



*Source:* NWSV

In addition, the NWSV has rights to a number of smaller fields in Figure 1 which are the subject of ongoing exploration and or appraisal.

This NWS group of fields are connected by the North West Shelf trunklines to the Burrup Peninsula near Dampier, where the NWS Project's LNG and domestic gas processing facilities are located (Figure 2)

Figure 2 **Western Australia's gas developments and pipelines**




*Data source:* www.era.gov.au

Processing of gas on the Burrup Peninsula is undertaken at the Karratha Gas Plant, which includes five LNG processing trains, two domestic gas trains, six condensate stabilisation units, three fractionation units as well as storage and loading facilities for LNG, LPG and condensate.

### 2.1.1 Ownership

The NWSV consists of the following six integrated production unincorporated joint ventures, each of which Woodside operates:

- Domestic Gas Joint Venture (DGJV) – produces natural gas for sale to industrial customers and to utilities for household use and power generation in Western Australia
- Incremental Pipeline Gas Joint Venture (IPGJV) – produces natural gas for sale to Western Australian customers once certain production thresholds are reached
- LNG Joint Venture – produces LNG for sale
- LPG Joint Venture – extracts LPG produced from the North West Shelf gas streams
- China LNG Joint Venture – supplies LNG to the Guangdong LNG project in China (but does not own NWS Project infrastructure)
- The Cossack-Wanaea-Lambert-Hermes (CWLH) Joint Venture – develops and produces oil from Cossack, Wanaea, Lambert and Hermes oil fields.

The NWS Domestic Gas Joint Venture has the following ownership structure:

- BHP Billiton Petroleum (North West Shelf) Pty Ltd (8.33 per cent)
- BP Developments Australia Pty Ltd (16.67 per cent)
- Chevron Australian Pty Ltd (16.67 per cent)
- Shell Development (Australia) Pty Ltd (8.33 per cent)
- Woodside Energy Ltd (50 per cent).

The NWS LNG, IPGJV and LPG Joint Ventures have the following ownership structure:

- BHP Billiton Petroleum (North West Shelf) Pty Ltd (16.67 per cent)
- BP Developments Australia Pty Ltd (16.67 per cent)
- Chevron Australian Pty Ltd (16.67 per cent)
- Japan Australia LNG (MIMI) Pty Ltd (16.67 per cent)
- Shell Development (Australia) Pty Ltd (16.67 per cent)
- Woodside Energy Ltd (16.67 per cent).

The China LNG Joint Venture has the following ownership structure:

- BHP Billiton Petroleum (North West Shelf) Pty Ltd (12.5 per cent)
- BP Developments Australia Pty Ltd (12.5 per cent)
- Chevron Australian Pty Ltd (12.5 per cent)
- China National Offshore Oil Corporation (CNOOC) (25 per cent)
- Japan Australia LNG (MIMI) Pty Ltd (12.5 per cent)

- Shell Development (Australia) Pty Ltd (12.5 per cent)
- Woodside Energy Ltd (12.5 per cent).

CNOOC also holds a just over 5 per cent interest in the NWSV titles, with right to use NWSV infrastructure to produce and process gas from the acquired gas resources.

The Cossack-Wanaea-Lambert-Hermes (CWLH) Joint Venture has the following ownership structure:

- BHP Billiton Petroleum (North West Shelf) Pty Ltd (16.67 per cent)
- BP Developments Australia Pty Ltd (16.67 per cent)
- Chevron Australian Pty Ltd (16.67 per cent)
- Japan Australia LNG (MIMI) Pty Ltd (16.67 per cent)
- Woodside Energy Ltd (33.33 per cent).

Woodside acquired Shell Development (Australia) Pty Ltd's 16.67 per cent interest in the CWLH joint venture in May 2008.

In addition, there are two joint ventures in place for potential future development of the separate Dixon and Egret discovery areas.

### 2.1.2 NWSV history

The NWSV was initially formed in 1963 between Woodside, Shell and Burmah Oil to pursue offshore petroleum and gas discovery opportunities. The history of the NWS Project commences in the early 1970s, following the discovery by the original NWSV participants of significant quantities of natural gas and condensate in the Carnarvon Basin off the Pilbara Coast in Australia's North West.

Construction of the NWS Project infrastructure commenced in 1980 and it was the largest private sector construction project Australia had ever experienced. Domestic gas facilities providing additional natural gas for Western Australia were constructed first, and commissioned in August 1984. Subsequently, the LNG production infrastructure was progressively developed, with the following commissioning dates and capacities:

- 1989 – LNG Train 1 (2.5 million tonnes a year)
- 1989 – LNG Train 2 (2.5 million tonnes a year)
- 1992 – LNG Train 3 (2.5 million tonnes a year)
- 2004 – LNG Train 4 (4.4 million tonnes a year)
- 2008 – LNG Train 5 (4.4 million tonnes a year).

To date, the NWSV has signed off on investments totalling around $27 billion in nominal dollars for its oil and gas production facilities, which include offshore production platforms and subsea infrastructure, onshore processing and storage facilities at the Karratha Gas Plant, loading facilities, jetties, shipping and associated infrastructure. For the purposes of this report, economic modelling involving a core ($19.58 billion) subset of this expenditure was used to inform the scale of the economic impacts flowing from the LNG component of the NWS Project (Table 1).[1] The report will thus understate to a degree the total impact of the NWS Project – to the extent that not all of the investments made by the NWSV are included in the analysis.

Table 1 **Core NWSV construction expenditures**

| | Nominal dollars of the day | 2008-09 real dollars |
|---|---|---|
| | $m | 2008-09$m |
| Phase 1 | 2,500 | 7,213 |
| Phase 2 | 2,995 | 5,969 |
| Phase 3 | 3,111 | 4,808 |
| Phase 4 and 5 | 10,974 | 12,098 |
| Total | 19,580 | 30,088 |

*Data source:* ACIL Tasman analysis – based on Australian Bureau of Statistics 2009, Consumer Price Index, Australia, Woodside data and existing studies[1,2]

## Phase 1 development

Phase 1 of the development of the NWS Project began in 1980 with the construction of:

- the NWSV's onshore domestic gas plant in Karratha
- a jetty for the loading of LNG and condensate
- the North Rankin A offshore production platform and

[1] Table 1 includes those core capital expenditures on the NWS Project LNG infrastructure, through to 2008, on which the analysis in this report is based. It excludes some items of expenditure – such as on the Cossack Pioneer FPSO facility, shipping and the later additional investments in Phase 1 to 3 infrastructure (post 1993). Table 1 therefore does not cover all historic investments by the NWS Project, and will understate to degree the full impacts of the nominal $27 billion of investment committed to date.

[2] Clements K.W. and Greig R.A. 1994, *Modeling Large Resource Development Projects in an Open Economy: the Case of Australia's North West Shelf Gas Project*, Studies in Urban and Resource Economics, The Blackstone Company, Mt Pleasant, Michigan, pp. i-xviii, 1-151; Access Economics 1997, *North West Shelf Expansion Project: Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy; and Access Economics 1998, *North West Shelf Expansion Project: Supplementary Report: Western Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy.

- the 135 kilometre subsea pipeline (main trunkline) to shore.

Total expenditure on the first phase of development was around $2.5 billion in nominal dollars of the day, which equates to around $7.2 billion in 2008-09 dollars (see Box 1 for more detail on CPI escalation). This did not include the costs of the 1600 kilometre Dampier to Bunbury Natural Gas Pipeline.

The development of the domestic gas component of the NWSV was facilitated by agreement with the Government of Western Australia for a 20 year 'take or pay' gas supply contract, and government funding for the Dampier to Bunbury Natural Gas Pipeline. The 20 year take or pay agreements with the State Energy Commission of Western Australia were for 329 TJ/d of gas in 1985 and 414 TJ/d for the next 19 years.[3]

Domestic gas deliveries from the NWS Project to the South West of Western Australia commenced in 1984.

### Phase 2 development

In 1985, sales agreements with eight major Japanese power and utility companies for long term LNG supply were signed by the NWSV. Subsequently, work commenced on the second phase of development – the construction of the first two LNG processing trains and four LNG storage tanks at the Karratha Gas Plant.

Expenditure on this phase of the project was equivalent to around $6.0 billion in 2008-09 dollars. The construction program was completed in 1989, and the first shipment of LNG was delivered to Japan in August 1989.

### Phase 3 development

The third major phase of development saw the completion in 1992 of a third LNG train, followed by the commissioning in 1995 of the Goodwyn A offshore production platform, located 23 kilometres to the south-west of the North Rankin A platform.

In 1995 production of crude oil from the Cossack and Wanaea fields commenced from the Cossack Pioneer floating production storage and offtake (FPSO) facility. Oil from the Hermes and Lambert fields came on line in 1997.

[3] Clements K.W. and Greig R.A. 1994, op.cit, pp. 39.

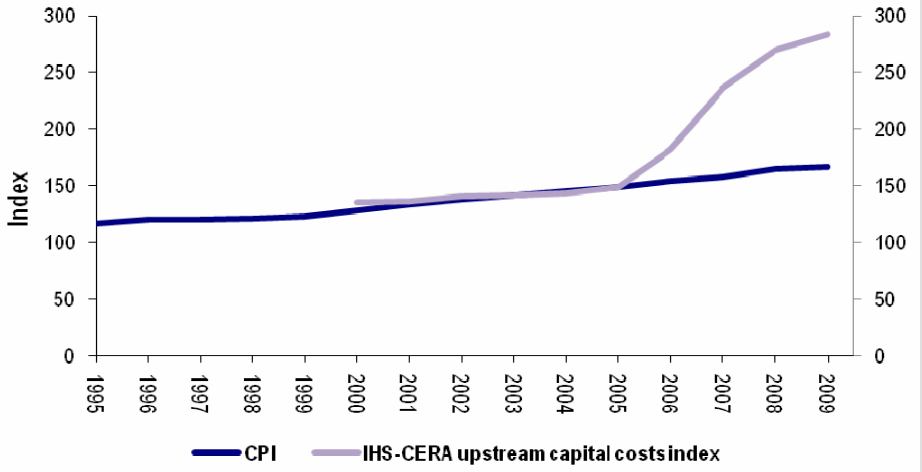
## Box 1 Cost escalation to today's dollars

Nominal 'dollars of the day' historic cost and revenue estimates were brought to a consistent basis through escalation by the Australian Consumer Price Index (CPI) to real 2008-09 dollar values. [4] On this basis, $1 in 1990 equates to $1.61 in 2008-09 dollars.

A single CPI cost escalator is used because it brings estimates into today's terms – while reflecting the changing expenditure power of a dollar for consumers. The conversion thus reflects the opportunity cost of the funds employed for consumers today – which provides an indicator of the overall economic welfare implications. In addition, the use of a single CPI cost escalator across all historic values – construction costs, operational expenditures and revenues – serves to maintain their size relative to each other. It is also computationally simple.

However, it should be noted that the 2008-09 construction cost estimates thus developed will tend to underestimate the cost of the facilities, compared to if they were being constructed today. This is because upstream construction costs for oil and gas facilities have risen sharply above CPI trends in the past few years, as indicated in the following Figure, which compares the Australian CPI index and recent estimates for the capital costs for the *global* upstream oil and gas industry.

**Australian all-groups CPI and IHS-CERA upstream capital cost indexes**




Anecdotal evidence suggests that construction costs for the Australian oil and gas industry have jumped even more sharply again. On this basis, the $27 billion of construction expenditure on the NWSV oil and gas facilities would require expenditure of more than $50 billion if they were to be constructed today.

Source: Australian Bureau of Statistics 2009, Consumer Price Index, Cat. 6401.0, March and ACIL Tasman analysis based on Cambridge Energy Research Associates 2009, Document 70113-3_2804.

[4] The CPI series used for this purpose was the Australian 'All groups' series, taken from Australian Bureau of Statistics 2009, *Consumer Price Index*, Cat. 6401.0, March.

At the end of 1995, new LPG extraction and storage facilities were commissioned and a second ship-loading jetty, adjacent to the original jetty, was built to load LPG and condensate. Debottlenecking of the onshore gas plant also lifted annual LNG production capacity to 7.5 million tonnes (2.5 million tonnes per year from each processing train).

Total expenditure for Phase 3 of the NWS Project was around $4.8 billion in 2008-09 dollars – comprising $1.5 billion in onshore expenditure, and $3.3 billion expenditure offshore on the Goodwyn A platform and associated pipelines.

### Phase 4 development

The fourth major phase of development began in early 2001 with the construction of a fourth LNG train with an annual capacity of 4.4 million tonnes and a second trunkline to shore. Train 4 achieved first production in 2004, increasing the NWS Project's total annual LNG production capacity to 11.9 million tonnes.

### Phase 5 development

The fifth major phase of development – the Phase 5 LNG Expansion – began in August 2005 and involved the construction of a fifth LNG train capable of processing up to 4.4 million tonnes annually, a second LNG loading berth and associated infrastructure. Following a three year construction period, Train 5 produced first LNG in August 2008, lifting the NWS Project's total annual production capacity to 16.3 million tonnes.

Construction of the NWS Project's third offshore production facility, the Angel platform, began in 2005 and first gas was produced for processing at the Karratha Gas Plant in October 2008.

### Future growth

In March 2008, the NWSV participants approved funding of the $5 billion North Rankin Redevelopment Project, which involves the installation of a second offshore gas processing facility (North Rankin B) alongside the existing North Rankin A platform. The project is scheduled for start-up in 2013 and will extend field life to around 2040. It will support the NWSV's future supply commitments.

Woodside acquired Shell Development (Australia) Pty Ltd's 16.67 per cent interest in the North West Shelf oil interests in May 2008, and in December 2008 the five Cossack, Wanaea, Lambert and Hermes oil venture participants (CWLH Joint Venture) approved funding of $1.8 billion for the replacement of

the Cossack Pioneer FPSO facility in 2010, and the replacement of associated subsea infrastructure.

The NWSV is also considering commercialisation of the Greater Western Flank gas area, which could involve development of up to 14 fields, to maintain long term supply to the Karratha Gas Plant.

Approximately a third of the NWSV's reserves have been produced to date.

# 3 Economic impacts of NWSV LNG

In what follows, we estimate the combined economic impacts for all phases of the NWS Project LNG facilities, covering:

- Phase 1 – offshore platforms and pipelines
- Phase 2 – LNG trains 1 and 2
- Phase 3 – LNG trains 3
- Phase 4 and 5 – LNG trains 4 and 5, and second trunkline
- overall five train LNG operations

To do this we draw on existing studies, and utilise our experience in evaluating other major LNG developments. The main existing studies of the economic impacts of the NWS Project are:

- Clements and Greig's 1994 study of the economic impacts of Phases 1, 2 and 3[5]
- Access Economics' 1997 and 1998 studies of the impacts of the Phase 4 and 5 Expansion Project.[6]

## 3.1 Methodology

In order to estimate the economic impacts of the NWS Project, we combine the estimates developed as part of the previous studies. We also draw on a range of other information about the economic impacts of major oil and gas developments in Western Australia.

We integrate this material to provide an overall assessment of the various phases of the NWS Project. To do this we develop a series of annual impacts in percentage terms, and then apply these to time series of the relevant economic variables to determine the overall impact of the NWS Project in any particular year. This is illustrated in Figure 3.

While every endeavour is made to bring estimates to a consistent basis, it needs to be said at the outset that the combined estimates are *indicative* – the time period involved and the different approaches under each of the studies utilised

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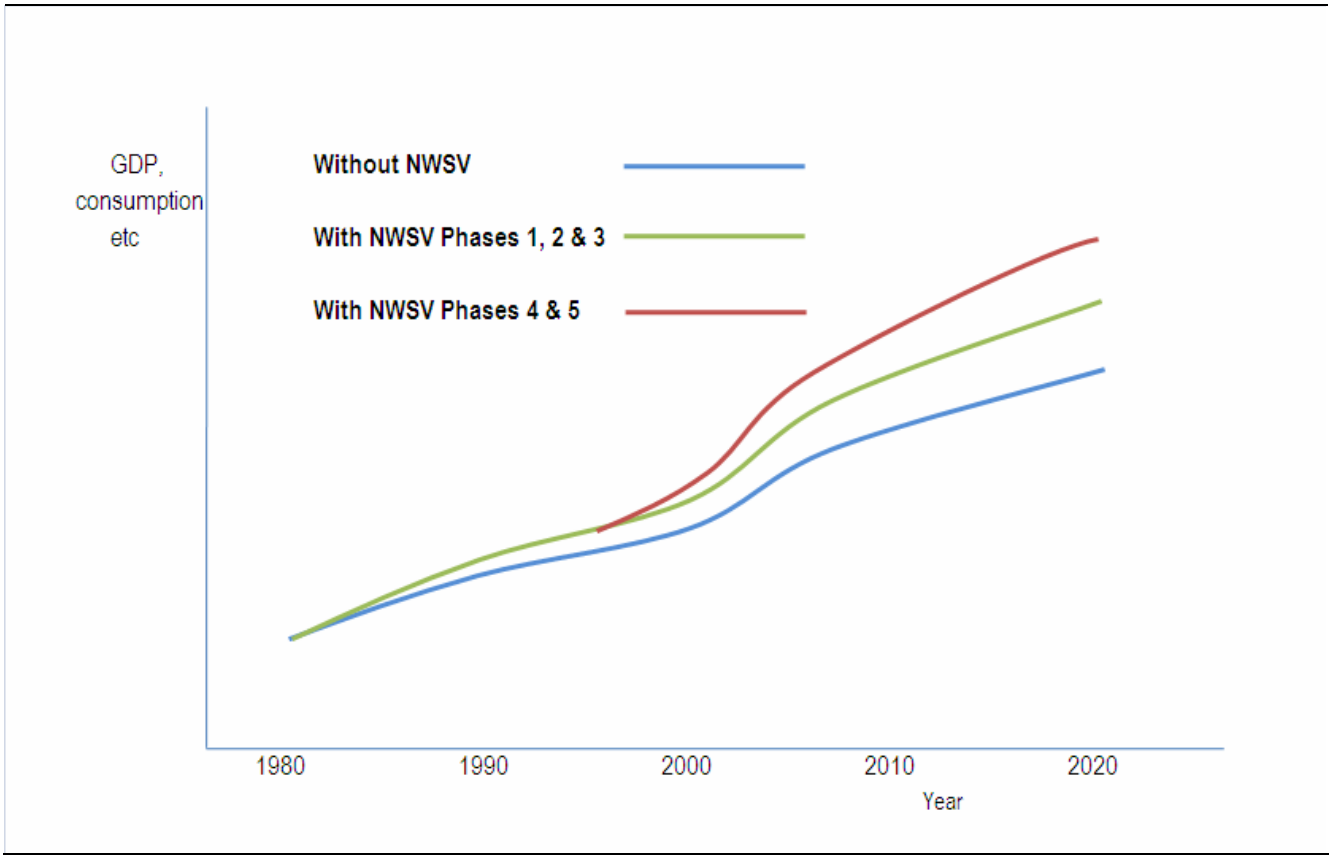
[5] Clements K.W. and Greig R.A. 1994, *Modeling Large Resource Development Projects in an Open Economy: the Case of Australia's North West Shelf Gas Project*, Studies in Urban and Resource Economics, The Blackstone Company, Mt Pleasant, Michigan, pp. i-xviii, 1-151.

[6] Access Economics 1997, *North West Shelf Expansion Project: Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy; and Access Economics 1998, *North West Shelf Expansion Project: Supplementary Report: Western Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy.

necessarily mean that indicative estimates are the best that can be achieved. For this reason, we have endeavoured to be conservative, and summary values are rounded to the nearest $100 million.

Figure 3 **Illustration of assessment methodology**




*Source:* ACIL Tasman

## 3.2 Phase 1, 2 and 3 LNG impacts

Clements and Greig evaluated the economic impacts of Phases 1, 2 and 3 of the LNG component of the NWS Project, using the comparative static Computable General Equilibrium (CGE) model ORANI. The study examined the construction and operational phases of the LNG Project separately – providing a typical 'snapshot' year impact for each phase. The study did not include the economic impacts of the domestic gas component of the NWS Project.

Construction expenditure figures in nominal 'dollars of the day' are provided by Clements and Greig for each Phase.[7] However, these cover a mix of

[7] Ibid, pp 42 to 46.

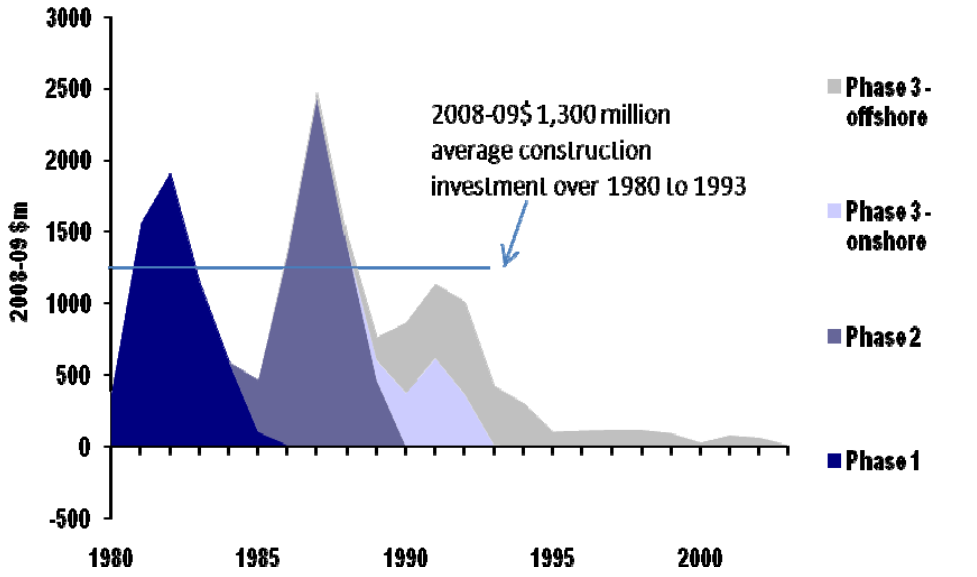
infrastructure for the LNG and domestic gas operations. Nevertheless, Clements and Greig noted that 'much of the infrastructure for Phase 1 is common to Phase 2', and thus would be necessary for the LNG Project to proceed.[8]

### 3.2.1 Construction investment in Phase 1, 2 and 3

In summary, expenditures on construction (Figure 4):

- in Phase 1 of the NWS LNG Project are estimated at around $2.5 billion in nominal dollars of the day – equivalent to around $7.2 billion in (close-to-current) 2008-09 dollars[9]
- in Phase 2 totalled $3.0 billion in nominal terms, equivalent to around $6.0 billion in 2008-09 dollars
- in Phase 3 construction expenditure totalled $4.8 billion in 2008-09 dollars, comprising $1.5 billion in onshore expenditure, and $ 3.3 billion expenditure offshore.

Figure 4 **Total construction investment – Phases 1, 2 and 3**




*Data source:* Clements and Greig 1994, op.cit. and ACIL Tasman analysis

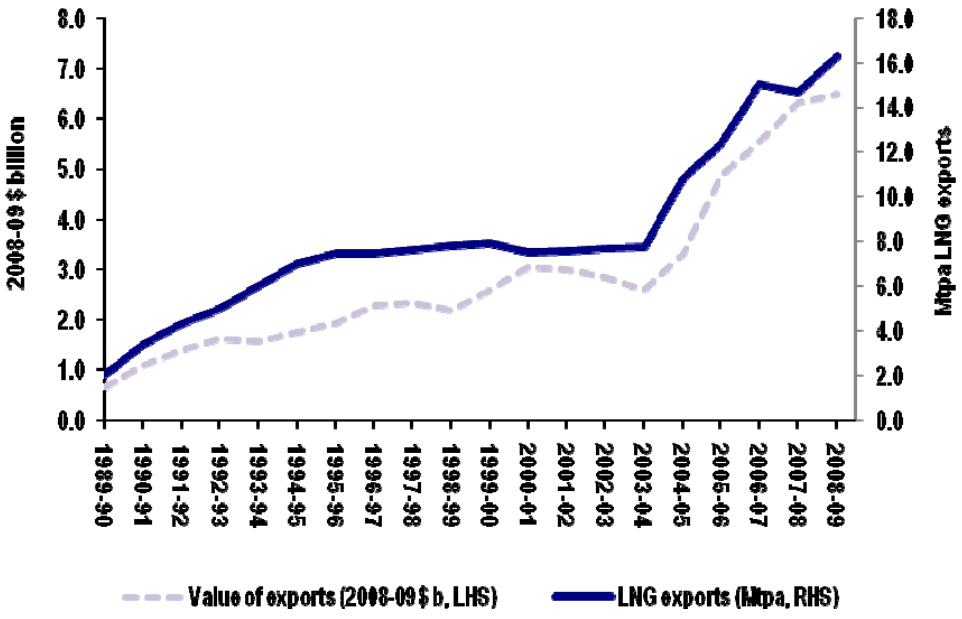
[8] Ibid, pp 40.

[9] All dollar of the day values were inflated by the annual CPI to bring these to 2008-09$. The CPI is the Australian 'All groups' series taken from Australian Bureau of Statistics 2009, *Consumer Price Index*, Cat. 6401.0, March (see Box 1 in Section 2.1.2 for further detail). Note that the expenditures reported by Clements and Greig for Phase 1 differ significantly from Woodside's data. Accordingly, we have used the Woodside data for Phase 1.

The total investment in the Phase 1 to 3 construction period was $18.0 billion in real 2008-09 dollars (Table 1).

The average *annual* investment expenditure over the main part of the construction phase – from 1980 to 1993 – was $850 million in 1989-90 dollars, or an estimated $1,300 million in 2008-09 dollars (also shown in Figure 4). This was a mammoth investment in its day, particularly for the economy of Western Australia. The average annual investment expenditure on construction of the NWS Project over the period 1980 to 1993 constituted more than 10 per cent of Western Australia's Gross Fixed Capital Formation (GFCF) in any year.[10] In the peak construction years of 1982 and 1987, the proportion would have exceeded 20 per cent of all private investment in the State.

Figure 5 **NWSV LNG exports**




*Data source:* ABARE Australian Commodity Statistics and ACIL Tasman analysis.

### 3.2.2 LNG production and revenue

LNG exports from the early Phases of the NWS Project climbed steadily through the early 1990s, before reaching a plateau around 7.5 Mtpa in 1994-95

[10] GFCF is defined as the 'outlays of producers on commodities which do not add to their inventories or enter into the intermediate consumption for the period… they yield benefits beyond the [immediate] period' (see Australian Bureau of Statistics 2000, *Australian System of National Accounts: Concepts, Sources and Methods*, www.abs.gov.au, pp 223. Note that the annual investment expenditure as a share of Australia's GFCF is estimated to have been in the range of 0.5 to 1.0 per cent.

with the successful 'debottlenecking' of Train 1, 2 and 3 production (Figure 5 – right hand axis). LNG exports then increased sharply in volume terms from 2004-05 – as first Train 4, and then Train 5 came on stream.

Corresponding real LNG export revenues climbed slowly through the 1990s, reflecting increasing oil prices (Figure 5 – left hand axis). The average value of LNG exports over the period 1991-92 to 2003-04 – a period of full production for Trains 1, 2 and 3 – was 2008-09 $2.3 billion. LNG export revenues have since grown rapidly – reflecting the commissioning of Trains 4 and 5, as well as the impact of rising oil prices in recent years. Total revenue earned by the NWS Project now approaches $60 billion in today's dollars.

### 3.2.3 Economic output and consumption impacts of the LNG component of Phases 1, 2 and 3

Clements and Greig estimated the macroeconomic impacts of the LNG components of the (Phases 2 and 3) of the Project. Their estimates were developed using the ORANI static CGE model – results are thus interpreted as being the average impacts which occur in a typical year of the respective Phase.[11] The 'average' construction investment shock is derived as follows:[12]

> The amount of investment in a typical year of the construction phase is calculated as the present value of the stream of investment (both already incurred and planned) [over the period 1980 to 1993] divided by the number of years in the phase, viz, 13. This yields $0.43 billion at 1980-81 prices, or $0.85 billion at 1989-90 prices.

The average construction expenditure of 1989-90 $850 million used for modelling the construction phase economic impacts – equivalent to $1,300 million in 2008-09 dollars – is shown in Figure 4.

For Clements and Greig's modelling purposes, the production phase was assumed to last for 10 years from 1994 to 2004 – with an assumed annual value of exports of $2.3 billion (in 1989-90 prices). This equates almost exactly with the actual average outcome for this period, as noted above.

The macroeconomic results developed by Clements and Greig are given in terms of the percentage deviation from an underlying 1980-81 base case which did not include the NWS Project (Table 2).[13]

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[11] 'In other words, the typical year refers to the average experience, rather than any particular year' (Ibid, pp xv).

[12] Ibid, pp 64.

[13] Note that the percentage deviations from the underlying 1980-81 input output table will be much larger than the percentage deviations from the current 2009 economy.

The Clements and Greig study was based on results from a version of the ORANI model which utilised economic input output tables with real 1980-81 data. In line with this, we use Australian Bureau of Statistic 1980-81 dollar values for economic variables such as GDP and real private consumption, in order to convert percentage impacts into real dollar values. These 1980-81 dollar values were then converted back to 1989-90 values through use of the CPI inflator.

As a further point to note, the original modelling results were scaled up by Clements and Greig by 16.7 per cent to reflect an expansion in LNG export capability from an original 6 Mtpa to 7 Mtpa. As noted in Section 2.1.2, debottlenecking subsequently allowed production of 7.5 Mtpa to be achieved with the initial gas processing plant. Assuming a linear response, this implies that the original results could be scaled up by a further factor of 7.1 per cent – which has also been applied to the operational phase estimates in Table 2. [14]

Table 2 **Annual economic impacts of the LNG components of Phases 1, 2 and 3**

| | Construction phase | Operational phase |
|---|---|---|
| | Percentage deviation | Percentage deviation |
| Australia | | |
| – Real total investment | 0.72 | -0.3 |
| – Real private consumption | 0.01 | 0.7 |
| – Real government expenditure | 0.01 | 0.5 |
| – Real GDP | -0.02 | 0.7 |
| – Real GNP | 0.01 | 0.5 |
| – Real wage rate | 0.09 | 0.6 |
| – Aggregate exports (foreign currency value) | -0.95 | 3.5 |
| – Aggregate imports (foreign currency value) | 0.30 | 0.9 |
| Western Australia | | |
| – Gross State Product | 0.79 | 8.1 |

*Note:* These results assume long run full employment – labour market impacts are reflected in the real wage rate.

*Data source:* Clement and Greig 2004, op cit.

[14] We also applied the scaling factor of 0.56 – identified by Clements and Greig – to the production phase results. Clements and Greig note: 'the original projection from the model… is an overstatement as the contribution of oil to aggregate exports in the model is based on a price of $US 35.65 per barrel'. This compares to the actual oil price assumed for the purposes of the study of $US 20. Accordingly, the results are scaled by (20/35.65 =) 0.56 (see footnote b to Table 5.1 on pp 65 of Clements and Greig 2004, op. cit. which refers).

### Construction phase impacts

Clements and Greig found little impact on the economy during the construction phase, driven in large part by assumptions about the source of capital and labour resourcing for this phase of the project.

However, our view is that major projects can lead to a significant impact in the construction phase – as the foreign investment provides a net injection to the domestic economy, with attendant increases in wages, profits and taxes paid locally, and short term net economic benefits.

Whatever the outcome, it is clear that the initial construction phases of the NWS Project provided a major stimulus to the oil and gas construction and services sector in Australia. These impacts are discussed in Chapter 4.

### Operational phase impacts

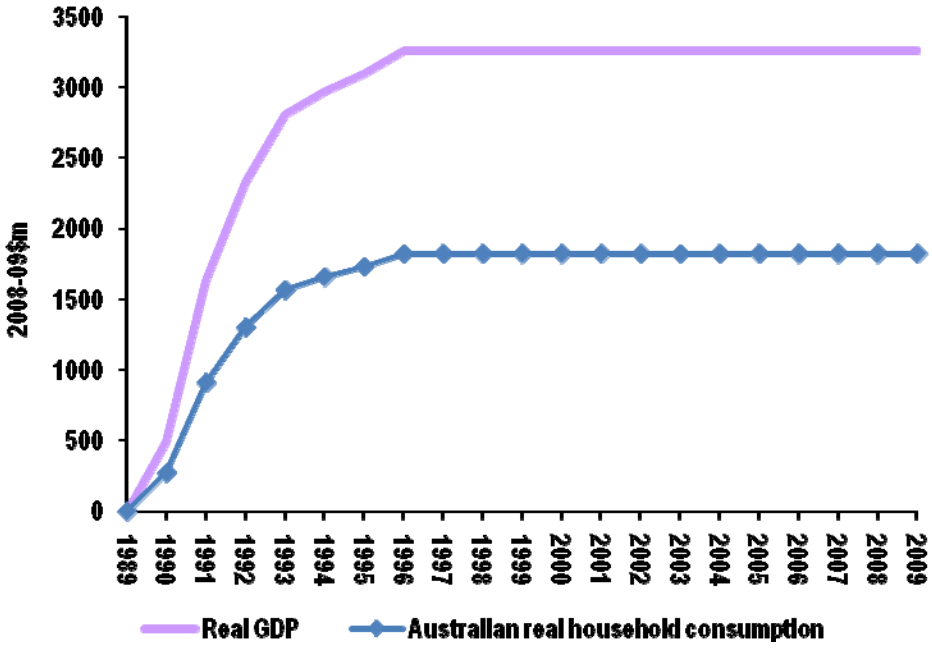
Export revenue of around $60 billion in 2008-09 dollars has been achieved to date since the first shipments of LNG in 1989. The average annual economic impact of this production is significant (Table 2). The Clements and Greig estimates suggest that:

- Australia's GDP has been increased each year – since full production was achieved – by an average of $3.3 billion in today's dollars compared to what would otherwise have occurred (Figure 6)
- Australian household consumption – a component of the change in economic welfare arising from the Project – is up by $1.8 billion each year on average in today's dollars (Figure 6)
- Western Australia's GSP has been increased by $4.4 billion each year on average in today's 2008-09 dollars, compared to a situation without the NWSV
- real wages were by up by 0.6 per cent in the 'average' year.[15]

Overall, the estimates suggest that production from Phase 1, 2 and 3 has delivered just over $30 billion in today's dollars in additional consumption for Australian households.

[15] This estimate is based on 'full employment' closure of the model – which assumes fixed real wages (see Section 3.2.5 below for further detail).

Figure 6 **GDP and real private consumption impacts – Australia – Phases 1, 2 and 3**




*Data source:* Clements and Greig 1994, op.cit. and ACIL Tasman analysis.

### 3.2.4 Taxation revenue

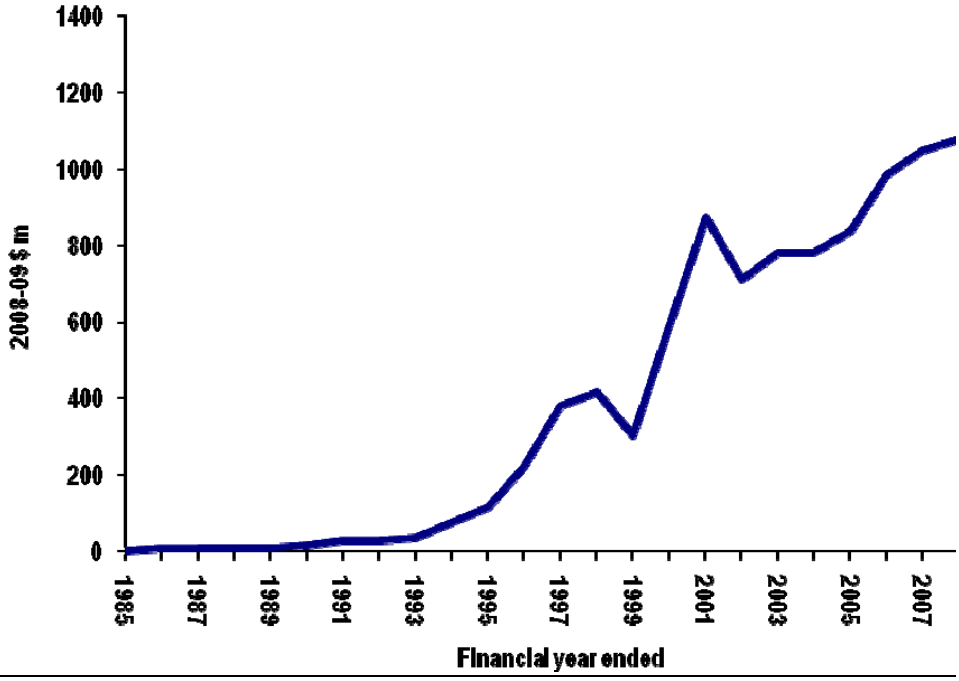
The NWSV pays royalties on its NWS production. Under the agreement struck at the commencement of the NWS Project, approximately one third stays with the Commonwealth, while the remainder is paid by the Commonwealth back to Western Australia. The rate is levied at between 10 and 12.5 per cent on wellhead value (sales value minus deductions for the costs of bringing gas from the wellhead to the point of sale). In 2008-09 the NWSV paid more than $1.2 billion in petroleum royalty revenues (Figure 7).

In addition, the NWSV pays excise to the Commonwealth on its crude and condensate production.

To date, the NWSV has paid around $15.7 billion in today's dollars in petroleum royalties and excise to the Commonwealth and Western Australian Governments.

In addition to petroleum and excise royalties, NWSV participants will have paid a range of other taxes over the years. Of these taxes, corporate tax will have been the most significant. However, Clements and Greig did not estimate the impact of the NWSV on corporate tax revenues.

Figure 7 **NWSV annual royalty payments**




*Data source:* Personal communication, Department of Mines and Petroleum, 12 August 2009.

### 3.2.5 Employment

The employment impacts of the NWS Project can be separated into the direct and indirect employment impacts.

#### Direct employment

Clements and Greig reported actual and projected Woodside operations staffing by location through to 1995 (Table 3). Direct employment numbers during the construction phase peaked in 1993 at 1,660 employees.

#### Indirect employment

Clements and Greig estimated the indirect employment increases that might have occurred had there been no real wage rises as a result of the NWS Project. Applying the scaling adjustments set out in Section 3.2.2 above to the Clements and Greig ORANI modelling results, suggests that as a result of the NWS Project, and absent real wage increases, a 'typical year' for NWSV Phase 1, 2 and 3 operations would result in employment in:

- Australia increasing by more than 50,000 persons
- Western Australia increasing by more than 40,000 persons.

Table 3 **Phase 1, 2 and 3 direct employment**

| | Offshore | Karratha | Perth | Other sites | Total |
|---|---|---|---|---|---|
| | number | number | number | number | number |
| 1980 | | | 550 | | 550 |
| 1981 | | | 791 | | 791 |
| 1982 | | | 914 | | 914 |
| 1983 | | | 892 | | 892 |
| 1984 | | | 987 | | 987 |
| 1985 | 131 | 330 | 810 | 45 | 1,316 |
| 1986 | 150 | 411 | 769 | 29 | 1,359 |
| 1987 | 224 | 397 | 789 | | 1,410 |
| 1988 | 194 | 461 | 673 | | 1,328 |
| 1989 | 213 | 498 | 663 | | 1,374 |
| 1990 | 215 | 537 | 747 | 86 | 1,585 |
| 1991 | 193 | 560 | 776 | 118 | 1,647 |
| 1992 | 160 | 547 | 750 | 4 | 1,461 |
| 1993 | 237 | 566 | 856 | 1 | 1,660 |
| 1994 | 225 | 516 | 733 | 1 | 1,475 |
| 1995 | 218 | 498 | 769 | 1 | 1,486 |

*Data source*: Clements and Greig 1994, op. cit., pp 50.

However, while it is likely that additional employment did result from the NWS Project, we do not consider the fixed real wages assumption to be realistic. First, the upstream oil and gas sector, and its intermediate input industries, employ specialised labour, which cannot be expanded quickly and which would be expected to derive higher real wages as demand increased. Secondly, the labour market arrangements of the late 1980s and early 1990s meant that higher wages in oil and gas and associated industries would have spread quite rapidly to other mining sectors. As a result, it is our view that a labour market outcome with higher real wages, and consequently significantly smaller employment number impacts, was likely.

## 3.3 Phase 4 and 5 LNG impacts

Access Economics assessed the economic impacts of the North West Shelf Expansion Project based on a near doubling of the annual LNG export capacity, from 7.5 Mtpa to 14.5 Mtpa, an increase of 7.0 Mtpa.[16]

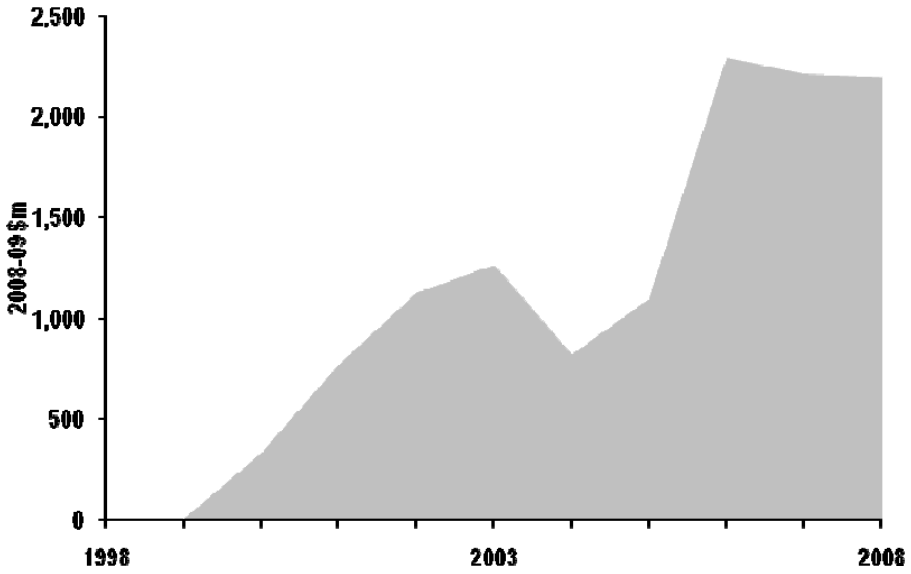
[16] Access Economics 1997, *North West Shelf Expansion Project: Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy; and Access Economics 1998, *North West Shelf Expansion Project: Supplementary Report: Western Australian Economic and Fiscal Impacts*, photocopy provided by Woodside Energy.

As executed, Phases 4 and 5 of the NWS Project resulted in an increase in capacity of 8.8 Mtpa – see Section 2.1.2. In the following sections, we scale up the Access Economics results to account for this higher output than was originally modelled.

### 3.3.1 Construction investment in Phases 4 and 5

The construction period for Phases 4 and 5 was modelled by Access Economics for the period 1998 to 2007. The total construction expenditure over the period was around $11.7 billion in 2008-09 dollars (Figure 8).[17]

Figure 8 **Phase 4 and 5 construction expenditure**




*Data source:* ACIL Tasman analysis

### 3.3.2 Production and revenue

Production from Phase 4 operations commenced in June 2004 and from Phase 5 in August 2008, boosting production and revenue for the NWSV (Figure 5). As noted above, total revenue earned by the NWS Project to date approaches $60 billion in today's dollars.

[17] Access Economics 1997, *North West Shelf Gas Expansion Project: Australian Economic and Fiscal Impacts* (photocopy of original unpublished report provided by Woodside). Total expenditure of $6.5 billion in 1997 dollars reported by Access Economics was scaled up for the ultimately increased size of the Phase 4 and 5 facilities, and then inflated to 2008-09 dollars.

### 3.3.3 Economic output and consumption impacts of the LNG component of Phases 4 and 5

Access Economics assessed the economic impacts of Phases 4 and 5, covering the capital investment phase from 1999 through to 2007, and an operational phase from 2003 to 2019. They report results for modelling of two assumed states of the world:

- a fixed employment outcome – where Australia's total employment is assumed to remain unchanged
- a variable employment outcome – where the total employment nationally is allowed to increase in response to the economic stimulus arising with the NWS – which implies idle labour resources.

With assumed fixed employment, the NWS Expansion Project is estimated to deliver increased GDP of just under $4 billion per annum in 2008-09 dollars by 2013, with national real private consumption up by just over $2 billion on the same basis (Table 4 and Figure 9). Real wages were estimated to increase by 0.24 per cent nationally.

For Western Australia, the corresponding annual boost to GSP in 2013 is just over $3 billion in 2008-09 dollars.[18] Real private consumption in Western Australia is up by $258 million on similar terms.

There are additional multiplier effects when increased total employment is allowed in the modelling assumptions:

- Australia's GDP is up by $7.6 billion in 2008-09 dollars in 2013, while Australia's real private consumption is up by $5.1 billion
- Western Australia's GSP is up by $3.6 billion in 2008-09 dollars in 2013, while Western Australia's real private consumption is up by $0.7 billion.

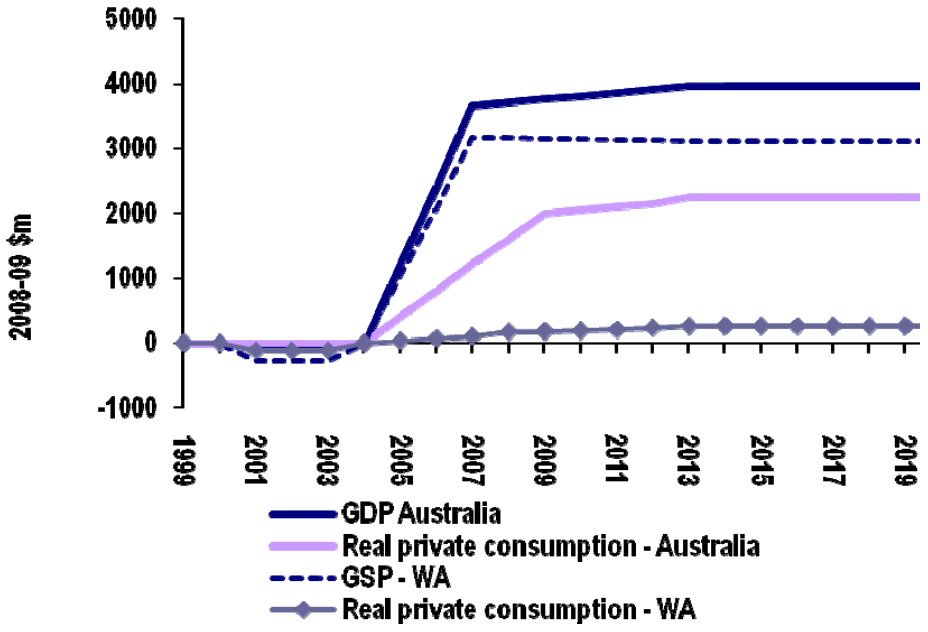
[18] The fact that the boost to GSP is less than for national GDP suggests that Access Economics assumed a high proportion for local content, with a significant proportion of that expenditure outside of Western Australia.

Table 4 **Economic impacts – Phase 4 and 5**

| | Construction phase (snapshot at 2002) | | Operational phase (snapshot at 2007) | | Operational phase (snapshot at 2013) | |
|---|---|---|---|---|---|---|
| | $m 2008-09 (or per cent) | | $m 2008-09 (or per cent) | | $m 2008-09 (or per cent) | |
| Employment assumption | Fixed | Up 10,000 | Fixed | Up 5,000 | Fixed | Up 25,000 |
| Australia | | | | | | |
| – Business investment | 1704 | 2005 | 445 | 594 | 346 | 1,094 |
| – Real private consumption | -6 | 1123 | 1212 | 1775 | 2,249 | 5,068 |
| – GDP | -45 | 1419 | 3665 | 4397 | 3,963 | 7,622 |
| – GNE | 1700 | 3128 | 1655 | 2369 | 2,595 | 6,160 |
| – Real wage rate | 0.04% | 0.04% | 0.15% | 0.17% | 0.24% | 0.35% |
| Western Australia | | | | | | |
| – Real private consumption | -116 | 655 | 102 | 303 | 258 | 704 |
| – GSP | -285 | 771 | 3176 | 3429 | 3,126 | 3,577 |
| – Real wage rate | 0.15% | 0.19% | 0.46% | 0.47% | 0.51% | 0.54% |

*Data source:* Access Economics 1997, op cit. and ACIL Tasman analysis.

Figure 9 **Economic impacts – Phase 4 and 5 – fixed employment**




*Data source:* Access Economics 1997, op cit and ACIL Tasman analysis.

### 3.3.4 Taxation revenue

The petroleum royalties and excises paid by the NWSV are set out in Section 3.2.4.

Access Economics estimated the total tax revenue impacts for Phase 4 and 5. In the Access Economics modelling, tax revenues are maximised when employment is allowed to increase as a result of the Project. Total annual revenues for the Commonwealth are estimated to rise by between $1.4 billion (fixed employment) and $2.5 billion (variable employment) in 2008-09 dollars during the mature operational phase (based on the annual snapshot at 2013), compared to a case where the Phase 4 and 5 expansion had not proceeded, and to deliver up to around $0.3 billion additional state and local government revenue for Western Australia (Table 5).

Interpolating these results through to 2020 informed by production levels, and summing the resulting annual estimates, suggests that Phase 4 and 5 will boost Commonwealth revenues by up to $32.1 billion in (undiscounted) 2008-09 dollars in total, and Western Australian State and local government revenues by $3.7 billion.

Table 5 **Tax and royalty revenues – variable employment closure**

| | Construction phase (snapshot at 2002) | Operational phase (snapshot at 2007) | Operational phase (snapshot at 2013) |
|---|---|---|---|
| | 2008-09 $m | 2008-09 $m | 2008-09 $m |
| Commonwealth | 531 | 887 | 2,528 |
| Western Australia State and local government | 47 | 199 | 256 |

*Note:* Assumes employment nationally expands as a result of the NWSV operation.

*Data source*: Access Economics 1997, op.cit, pp 19; Access Economics 1998, op. cit., pp 9; and ACIL Tasman analysis

### 3.3.5 Employment

As outlined above, Access Economics modelled a case where total national employment was allowed to increase. This case assumed idle labour resources were available to allow the expansion in national employment. However, given the close to full employment experience in Australia over the past few years, we consider that the actual employment outcomes will have been a mix of real wage increases and employment increases.

That said, the potential employment impact reported by Access Economics of the Phase 4 and 5 expansion, assuming idle labour resources, is for:

- more than 10,000 full time equivalent jobs nationally in the peak construction period 2000 to 2005, with the great majority of these jobs in Western Australia
- up to 40,000 jobs nationally in the operational period 2011 to 2020, with around two thirds of these occurring in Western Australia.[19]

## 3.4 Future investment

The NWS Venture participants continue to invest in developing infrastructure – with more investment in hand or planned for the near future, including:

- $5 billion for the North Rankin Redevelopment Project, and
- $1.8 billion for the redevelopment the NWS Cossack, Wanaea, Lambert and Hermes oil field production facilities.

## 3.5 Conclusions

The NWS Project is one of the largest resource projects ever undertaken in Australia, involving construction expenditures of more than $27 billion (Figure 10):

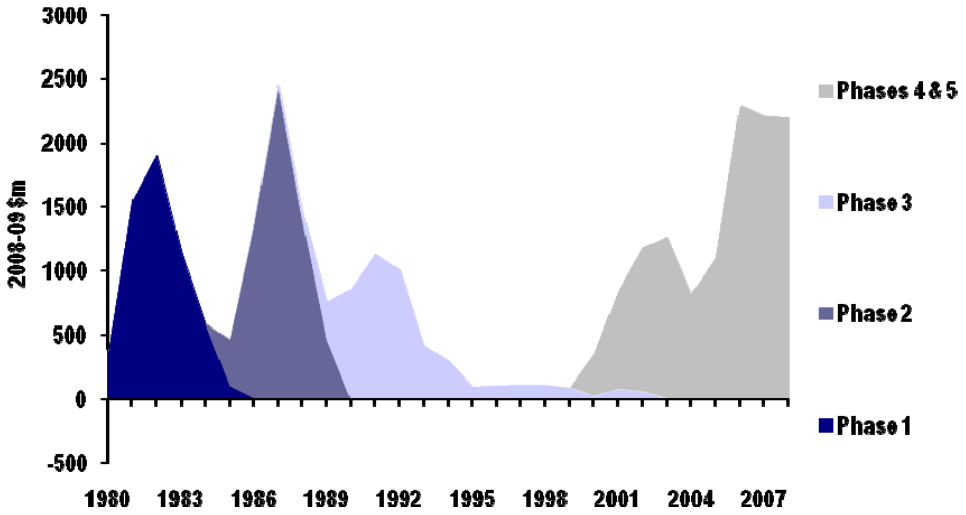
- Construction expenditures of more than $50 billion would be required to build the NWS Project facilities today.

In summary, the NWS Project has generated (all in undiscounted real 2008-09 Australian dollars):

- export revenues approaching $60 billion
- increased GDP for Australia totalling more than $70 billion over the period 1989 to 2009
  - annual contributions to Australia's GDP have grown to around $7 billion per annum, which will be maintained through the period 2010 to 2019 (Figure 11)
  - this represents a boost to annual GDP of around 0.7 per cent
- increased GSP for Western Australia approaching $90 billion over the period 1989 to 2009
  - annual contributions to Western Australia's GSP have grown to approach $8 billion per annum, which will be maintained through the period 2010 to 2019

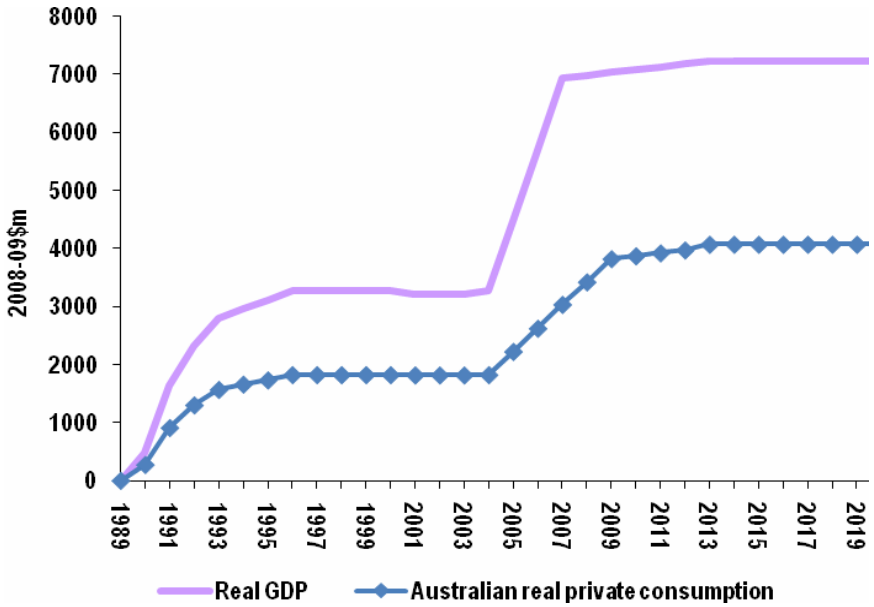
[19] The national employment figures reported here are based on the results of the AE-Macro model. The share in this total employment figure for Western Australia is based on the proportions derived from the input-output analysis conducted by Access Economics.

Figure 10 **Phases 1 through 5 investment**




*Data source:* Clements and Greig 1994, op.cit, Woodside Energy data and ACIL Tasman analysis

Figure 11 **NWS Project total GDP and private consumption impacts - Australia**




*Data source:* ACIL Tasman analysis

  - this represents a boost to annual GSP of around 5 per cent
- increased consumption for Australian households approaching $40 billion over the period 1989 to 2009[20]
  - annual contributions to Australian's real private consumption are anticipated to reach more than $4 billion per annum in the period 2010 to 2019
  - more than 80 per cent of this increased consumption is estimated to accrue to Western Australia
- total petroleum royalty and excise revenues of more than $15 billion over the period 1989 to 2009
  - annual royalty payments by the NWSV now exceed $1.2 billion per annum – delivering more than $800 million to Western Australia and $400 million to the Commonwealth
- company and other taxation impacts for Phases 4 and 5 are estimated to be boosting Commonwealth revenues by up to $1.6 billion per annum (assuming a mix of wage increases and flow-on employment impacts), and Western Australian State and local government revenues by $40 million[21]
  - given relative sizes, we estimate that Phases 1, 2 and 3 will be delivering similar revenues
  - overall then, adding in the royalty revenues, it is reasonable to infer that the total taxation benefits for the Commonwealth from the NWSV are approaching $4 billion per year, and for Western Australian State and local governments, to be around $900 million per year[22]
- a mix of increased real wages and additional employment.

---

[20] This consumption expenditure is the real private expenditure on goods and services that are used for the direct satisfaction of individual or collective needs or wants. It excludes investment expenditures on fixed assets (including dwellings) and other non-financial assets. It includes consumption expenditure undertaken by the households sector, but not by the general government sector. It is thus a key measure of the change in Australian households' economic welfare.

[21] For the Commonwealth company and other taxation figure, we assume that the taxation revenue is around halfway between the fixed and variable employment closure values for 2009, net of royalties.

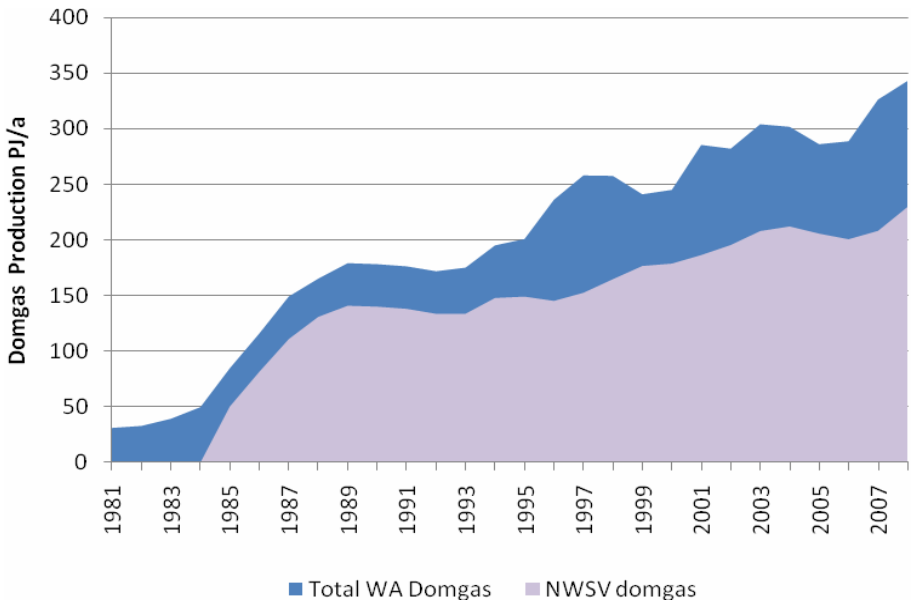
[22] The Commonwealth revenue estimate is made up by doubling the $1.6 billion per annum company and other tax revenue estimate for 2009, and adding on $400 million for the Commonwealth's share of the total royalty revenue. The State's revenue estimate is made up by doubling the $40 million per annum company and other tax revenue, and adding on $800 million for Western Australia's share of the total royalty revenue.

# 4 The contribution of NWS Project domestic gas to Western Australia

Prior to the development of the NWS domestic gas supply in 1984, natural gas consumption in Western Australia was only about five per cent of present levels. Gas supply was limited to relatively small volumes available from the Perth Basin and delivered to the Perth area through the Parmelia Pipeline.

However, the opening up of the North West Shelf fields in 1984, through the NWSV development and the associated completion of the Dampier to Bunbury Natural Gas Pipeline, allowed the Western Australian domestic gas market to grow rapidly. Domestic gas demand in Western Australia has expanded by 7 per cent in compound average growth terms since that time, to exceed 350 PJ/annum in 2008 (Figure 12). Such strong growth could not have occurred without the NWS Project.

Figure 12 **Western Australian gas production 1980 - 2008**

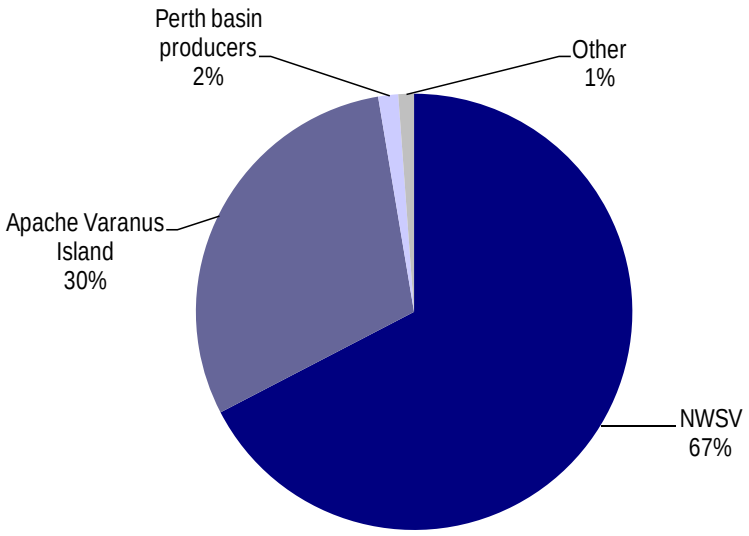



*Data source:* WA Department of Industry and Resources and ACIL Tasman estimates

## 4.1 The importance of NWS Project domestic gas

The NWS Venture's Karratha Gas Plant is currently Western Australia's largest producer of domestic gas, accounting for about 65 per cent of total State production (Figure 13). This equates to around $770 million worth of gas supply annually.[23]

Figure 13 **Shares of Western Australia's domestic gas supply in 2007**




*Data source:* WA Department of Industry and Resources and ACIL Tasman estimates

The NWS Project domestic gas facility includes two domestic gas processing trains that are together capable of processing about 600 TJ/day of gas (Table 6). Total Western Australian domestic gas processing capacity is currently in excess of 1,200 TJ/day (or around 440 PJ/annum), but much of this capacity is underutilised. This is particularly the case in the Perth Basin where aggregate processing capacity is around 50 PJ/annum while annual production is currently only 7.5 PJ, due to run down of gas resources.

[23] In 2008, the total value of natural gas consumed in Western Australia was valued at $1.19 billion (Department of Mines and Petroleum 2009, *Western Australian Mineral and Petroleum Statistics Digest 2008*, www.dmp.wa.gov.au).

Table 6 **Western Australia domestic gas processing plants**

| Operator | Plant Location | Basin | Plant Capacity (TJ/day) |
|---|---|---|---|
| Woodside Energy (North West Shelf Venture) | Dampier/ Burrup Peninsula | Carnarvon | 600* |
| Apache Energy (Harriet, East Spar and John Brookes JVs) | Varanus Island | Carnarvon | 350 |
| Chevron | Thevenard Island | Carnarvon | 21 |
| Origin Energy Resources | Onslow | Carnarvon | 25 |
| Australian Pipeline Trust | Dongara | Perth | 100 |
| AWE | Woodada | Perth | 10 |
| Origin Energy Resources | Beharra Springs | Perth | 30 |
| **Total** | | | **1,100 approx.** |

*Note:* * Dual processing trains

*Data source:* WA Department of Industry and Resources and Western Australian Office of Energy

Domestic gas in Western Australia is used by households and businesses, with the vast majority of use being in large scale industry. Domestic gas is thus a key facilitator of business activity in the State. However, the production of domestic gas in itself produces benefits to the WA economy. Using input-output multipliers, the direct and indirect flow-on contribution to Western Australia's Gross State Product (GSP) from the NWS Project's domestic gas supply operations is estimated to be around $750 million.[24] In addition, on the basis of an estimated oil and gas sector total employment multiplier of 1.20, the NWS domestic gas operation contributes directly and indirectly to over 900 jobs in Western Australia. It is important to note that these contributions to GDP and employment are separate to those of the downstream industries which use the domestic gas. The downstream impacts are discussed in Section 4.2.2 below.

## 4.2 Domestic gas use in Western Australia

The vast majority of natural gas in Western Australia is utilised for industrial purposes and power generation. Five large customers, Alcoa, Alinta, BHP Billiton, Burrup Fertilisers and Verve Energy, account for 90 per cent of gas consumption in Western Australia.[25] Power generation, alumina refining, and

[24] Prime Research (2009). Unpublished input-output multipliers for Western Australia.

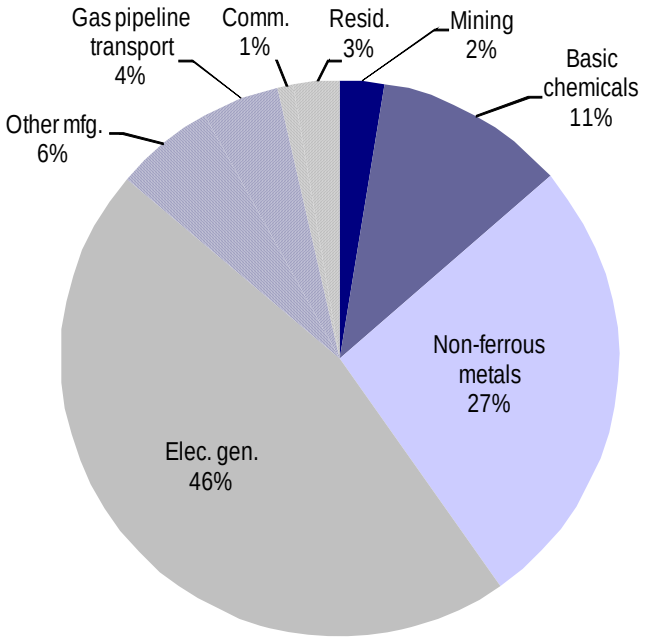
[25] Office of Energy 2009, *Gas Supply and Emergency Management Review: Public consultation package*, www.energy.wa.gov.au, pp 3.

resource processing and manufacturing in the South West accounts for over 80 per cent of existing gas demand.[26]

The Western Australian gas market is characterised by (Figure 14):

- a high proportion of direct gas sales in the industrial sector, predominantly for minerals processing and basic chemicals
- a high level of use of gas in power generation
- a relatively small utility (commercial/residential) sector reflecting the State's small population.

Figure 14 **WA natural gas consumption (non-LNG): by sector, 2007-08**




*Note:* ABARE classify cogeneration facilities to electricity generation, rather than to the industry sector which utilises the off-take heat.

*Data source*: ABARE 2007, *Energy Projections to 2029-30*, www.abare.gov.au.

The following sections outline the role of gas in each sector.

### 4.2.1 Commercial/residential sector

The commercial/residential sector includes use by households as well as commercial establishments, and therefore represents the "small customer" end of the market. The commercial/residential sector is significant only in the Perth area, where customers are served via a distribution system developed

[26] Domgas Alliance 2009, *Western Australia's Domestic Gas Security*, Submission to the Gas Supply and Emergency Management Review, www.energy.wa.gov.au, pp 46.

during the 1970s and 1980s. Because of the mild climate and consumer trends, use of gas in the residential sector for space heating is limited. Total direct consumption of gas in the commercial/residential sector is presently about 13 PJ per annum.

### 4.2.2 Industrial sector

The majority of gas consumption in the industrial sector in Western Australia is in the metals processing industries, particularly for non-ferrous metal such as alumina and nickel. Smaller volumes are consumed in petroleum refining, fertiliser production, cement and brick production, and smaller scale industries.

A significant portion of the industrial consumption of gas is in cogeneration facilities, where the steam output and a portion of the electricity are used in industrial processes. In some locations, the excess electricity production from these operations is sold into the local electricity grid.

Demand for industrial gas in Western Australia is determined primarily by competitive factors in end-product markets, and the price of alternative fuels locally. In remote areas outside the South West, petroleum products are the only viable alternative fuel, and gas can be competitive at much higher prices than in the South West. Hence, gas can be delivered economically over long distances via relatively low volume pipelines to remote areas of the state. The majority of the gas consumed in such remote areas is used in mining and related industries.

#### The alumina industry

The alumina industry is the largest consumer of natural gas in Western Australia. The south west corner of the State is the largest alumina region in the world, producing about 15 per cent of global supply. Demand at the four existing alumina refinery sites (Alcoa's Pinjarra, Wagerup and Kwinana refineries, and BHP Billiton's Worsley refinery) totals some 110 PJ/annum – approaching a third of Western Australia's total domestic gas consumption.[27] These operations would not have developed to this scale without the availability of the large scale, secure natural gas supplies provided by the NWSV (Box 2).

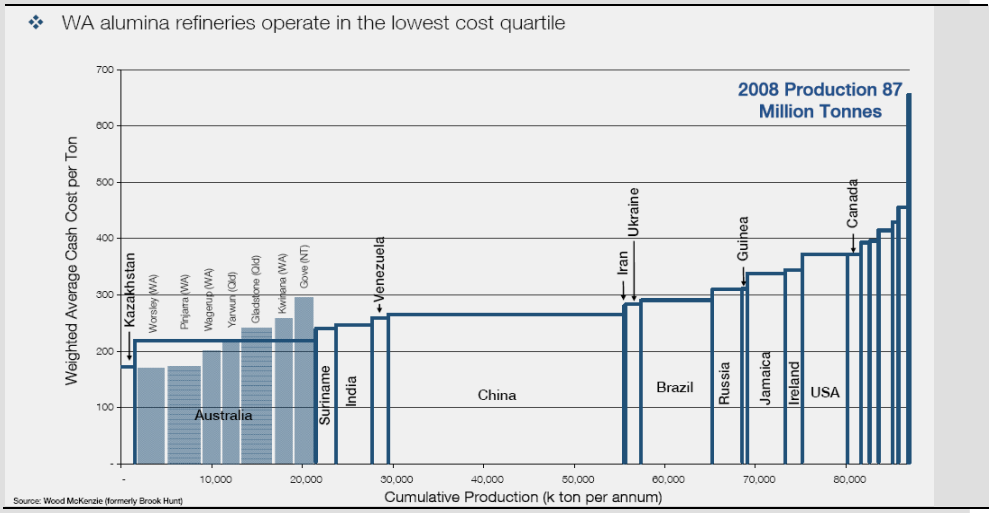
[27] Western Australia's total alumina production totalled 12.25 million tonnes in 2008, which was valued at around $4.9 billion. Input-output multiplier analysis suggests that alumina production contributed an additional $3.8 billion to Western Australia's Gross State Product (over and above the contribution derived from the gas used in the process outlined above), supporting a total of 14,700 jobs in the State.

## Box 2 Alcoa and the NWS Project

Alcoa is the largest alumina producer in Western Australia. Alcoa's Kwinana alumina refinery – the oldest in the State – began operations using fuel oil for its energy needs, which comprise around 25 per cent of total costs. In the 1970s, when gas became available from the Perth Basin via the Parmelia Gas Pipeline, the Kwinana refinery and Alcoa's newer Pinjarra Refinery switched to gas. In the 1980s, Alcoa committed to taking 50per cent of the gas from the North West Shelf domestic gas project, becoming the major foundation load for the development of the NWS Project. Today, Alcoa's Kwinana, Pinjarra and Wagerup refineries all use gas from the NWS Project.

The competitive cost of natural gas compared to the original fuel oil used at Kwinana contributed to Alcoa's production costs being in the bottom quartile of the world cost curve in 2008 (see Figure 15).

### Figure 15 Alumina world cost curve 2008




*Data source:* DUET Group 2009, I*nvestor Presentation, May 2009*, www.duet.net.au, slide 33.

Given 2008 gas and fuel oil prices, the use of natural gas is estimated to reduce the cost of alumina production by around an estimated US$125 per tonne.[28] Referring to Figure 15, eliminating this cost advantage would lift the operating cost of Alcoa's refineries into the third quartile of the world cost curve. [29]

[28] This calculation is based on the Alcoa refineries using approximately 11.5 GJ per tonne of alumina.

[29] Alumina refineries use most of their energy consumption in the production of electricity and steam, and around 30 per cent in the process of calcination – where hydrated alumina is heated to drive off water and create the alumina end product. The Worsley Alumina Refinery in South West Western Australia uses natural gas for the calcination process and coal for the generation of electricity and steam. If we assume that Alcoa's refineries could use coal to generate electricity and steam, and therefore only required fuel oil for calcination, then the incremental cost would be approximately US$37 per tonne.

There is significant potential for increased gas usage in the alumina industry. Current total alumina refinery capacity is about 10.8 million tonnes per year. Alcoa's Wagerup expansions, previously planned but put on hold, could add as much as an additional 4.7million tonnes of capacity. BHP Billiton's Worsley expansion is underway, increasing capacity from 3.5 to 4.6 Mtpa. First production is expected in the first half of 2011.

### 4.2.3 Electricity generation

In the South West region, most of the base load electricity generation requirement is supplied by coal-fired power stations, with a smaller quantity coming from cogeneration facilities. Stand alone gas-fired generators are used for intermediate and peaking service. However, as the electricity market continues to grow – and as carbon constraints lead to a greater share for renewables and low emissions base load – it is expected that gas will play a larger role in the base load mix.

# 5 Other economic development impacts

The NWS Project has required a considerable investment in infrastructure in the north west, leading to significant and sustainable regional development outcomes. It has also underpinned the development of a thriving oil and gas sector in Western Australia.

## 5.1 Regional development

The NWSV was a pioneer of development in the Pilbara, making a huge contribution to the development of Karratha.

Home to staff of the onshore component of the NWSV since 1984, Karratha since has developed to become the service and administrative centre for the Pilbara. It has the largest population of the Pilbara towns and has recently experienced strong population growth due to expansion of the minerals and energy sector. Its population of about 12,000 people puts it amongst the ten most populous centres outside Perth. Further, the town is maturing, with a slowly increasing proportion of the population becoming less transient and more stable (more than ten or 20 years residence), and a small but increasing number of older people.

The development of the oil and gas industry has helped drive the rapid economic and social development of Karratha. The industry, led by the NWSV, is a large employer of Karratha's residents. Currently, more than 400 people are employed at the Karratha Gas Plant. An additional 25 new employees and their families take up residence in the town each year to support the Gas Plant operations.

The oil and gas industry is an extremely important contributor to the Karratha economy. Based on input-output analysis, in 2005-06 the Gross Regional Product (GRP) at factor cost of Karratha was estimated to be $13.2 billion. Of this, the resources industry contributed over 95 per cent of Karratha's economy, with the majority contribution arising from the oil and gas sector.[30]

The NWSV has made significant investments in infrastructure and programs that support the social, cultural and economic capacity of the Pilbara community. The NWS Venture participants' investments in roads, housing,

[30] ACIL Tasman 2007, *The role of the Pilbara coastal towns in the Pilbara economy.*

health services and education in Karratha and the Shire of Roebourne now exceed $300 million. [31]

The NWSV Corporate Social Investment (CSI) Program focuses on strategic investment in local community projects and activities that aim to enhance the social, cultural and economic capacity of the Shire of Roebourne. The aim is to help to build a vibrant community through significant investments in infrastructure, programs and facilities. Examples of CSI investment are as follows.

### Karratha Education Initiative (KEI)

In 2007 the NWSV committed $1 million per year for three years to improve the standa-rd of secondary school education in the Karratha area. The KEI's principal aims are to:

- improve Tertiary Entrance Exam (TEE) standards and participation within Karratha
- enrich the secondary school experience for students and teachers in Karratha, and
- deliver educational opportunities and outcomes for students equivalent to those at high quality schools in Perth.

The KEI is also intended to:

- increase staff retention and the ability to attract new staff to the Karratha Gas Plant; and
- establish Karratha as an educational centre of TEE excellence in the north west.

### Shire of Roebourne Crime and Safety Initiative

For 2009, the NWSV has a sponsorship agreement with the WA Police to establish the Shire of Roebourne Crime and Safety Initiative. The initiative aims to:

- provide WA Police in the Shire of Roebourne with additional resources to implement targeted crime and prevention programs within the community which
  - help address and reduce the potential for anti-social and criminal behaviour within the Shire of Roebourne
  - reinforce behaviours that promote and enhance public safety

[31] North West Shelf Gas 2009, *North West Shelf Fact Sheet*, www.nwsg.com.au.

  - extend the range of law and order programs within the Shire of Roebourne to assist in law enforcement, and
  - provide resources and information to the local community on crime prevention strategies
- assist the Shire of Roebourne to better deliver services and make a safe community in which people want to live; and
- support Woodside's Karratha Gas Plant attraction and retention strategy by providing increased community services for residential employees and their families living in Karratha.

The initiative is implemented by the WA Police through individual projects.

### Mingullatharndo Enterprise Capacity

Mingullatharndo Aboriginal community (Five Mile) is located approximately 10 kilometres east of Roebourne.

A two year sponsorship of Five Mile by the NWSV is a pilot for a new approach between the NWSV and the local Aboriginal community. Through the support of key economic development opportunities, it is anticipated that this new approach will result in long term sustainable change and empowerment for Aboriginal groups. The sponsorship is designed to:

- increase the capacity of the Five Mile community to become economically self sufficient through the development of community owned and managed sustainable business ventures
- provide employment and training opportunities (including job readiness) for Aboriginal people residing within the Shire of Roebourne, through a combination of formal and informal work and training opportunities, designed and delivered in cooperation with the Five Mile community
- improve the self confidence and motivation of young Aboriginal people
- enhance the capacity of the Five Mile community to provide outreach services to other communities within the Shire of Roebourne, and
- improve the social and cultural environment for Aboriginal residents with the Shire of Roebourne.

## 5.2 Oil and gas industry development

As Australia's largest oil and gas resource development, the NWS Project has involved the construction of large scale, technologically sophisticated industry in a harsh, remote landscape and in challenging offshore conditions – pushing existing technologies and equipment to their limit.

The NWS Project required the application of leading technologies which had previously not been available in Australia.[32] Consequently, there was a need for technology transfer from overseas, as well as technological innovation to adapt that technology to Australia (Box 3).

Box 3 **Geographe Enterprises**

Geographe Enterprises is a provider of customised engineering solutions to the mining, exploration, and oil and gas industries. Founded in Western Australia by local engineer Neville Hyder in 1968, the company is a technology focused manufacturer of geared products and wear components. NWSV has been a Geographe client since the project began operation.

Geographe Enterprises is driven by research and development. It has pioneered production processes and cutting edge technologies for the provision of enhanced performance, task modified and replacement parts and services.

As an example, the failure of a crankshaft in an imported compressor on the NWS had the potential to disrupt production in the early 1990s. However, Geographe Enterprises was able to reverse engineer the component and manufacture and install a new crankshaft in less time than it would take one to be manufactured by the original equipment supplier from overseas.

The company now employs about 140 people dedicated to manufacturing and servicing high performing parts for fixed and mobile plant, with production facilities located in Perth and Bunbury. It has a well developed distribution system to facilitate national and international contracts across Australia, Asia, Europe and North America.

This technology transfer led to the NWS Project operator Woodside, and the local sub-contractor network, developing considerable expertise in LNG and domestic gas plant construction and associated technologies. At the same time, the local industry has become adept in developing remote deepwater fields, understanding meteorological and oceanographic conditions, and in applying related exploration and reservoir characterisation methods.

Technology development and deployment by Woodside includes projects undertaken by staff, collaborative research with large and small industry participants, and direct funding of university research, professorial chairs and other programs.

[32] Clements K.W. and Greig R.A. 1994, *Modeling Large Resource Development Projects in an Open Economy: the Case of Australia's North West Shelf Gas Project*, Studies in Urban and Resource Economics, The Blackstone Company, Mt Pleasant, Michigan, pp 90.

### 5.2.1 Technology and skill transfer

LNG liquefaction is a major example of introduction of a new technology to Australia by the NWSV. The Karratha plant was the first LNG plant in Australia and the introduction of this technology led to the development of new contractor capabilities and skills amongst the NWSV workforce. These capabilities, as well as other technologies developed and refined by the NWSV have been applied to the construction and operation of other new and proposed oil and gas developments.

### 5.2.2 Development of a petroleum service hub

The demand for technology and knowledge-intensive services by NWSV was the principal driver for the development of a petroleum service hub in Western Australia.

Service hubs can range from a collection of service companies to more formal collaborations between related organisations at either a physical or virtual level, in order to facilitate innovation and the transfer of knowledge. Organisations often work together, sharing skills, resources, infrastructure and ideas to service clients with complex, multi-disciplinary needs. Perth has developed as a service hub due to the significant presence of the oil and gas industry, with much of the impetus provided by the NSWV.

A report prepared for the Department of Industry and Resources in 2006[33] found that, as a result, Australia and Western Australia are in a strong position to benefit from changes taking place in global energy production and consumption patterns. They include the shift from oil to gas, the geographic shift to new producing regions including the Asia Pacific, the move to deep water and the rise of China and Asia as the fastest growing customers for energy.

The scale of capacity and the diversity of capabilities required of regional firms to service resources operations have led to clustering of innovative firms with complementary skills. The capabilities that have been developed are now utilised by many more exploration and production operations .

The services capacity of Perth is now such that the sector is a significant exporter in its own right. While specific petroleum services data is not

[33] ACIL Tasman 2006, *The Oil and Gas Industry: Expenditure trends and service providers*, a report to Department of Industry and Resources Western Australia.

available, data indicates that exports of engineering and other technical services from Western Australia rose to nearly $500 million in 2008.[34]

### 5.2.3 Development of local research capability

As existing conditions change and new projects are established, new challenges require innovative technological solutions. In response to particular challenges faced by the NSWV, technological improvements have been developed by Australian research at local institutions. Two examples are ISA Technologies (see Box 4) and the Centre for Offshore Foundation Systems.

Box 4 **ISA Technologies**

ISA Technologies is a specialist information technology company established in Perth's Technology Park. The company provides technical support and conducts collaborative research and development, with a particular focus on the oil and gas sector, for clients. The NWSV, through Woodside as operator, has been a major ISA client.

ISA Technologies has become a pioneer in developing innovative commercial applications for high performance computing (HPC) and visualisation in Australia. ISA Technologies HPC facility is a leading facility in Australia operating on a commercial basis to support 'Supercomputing On Demand' to a range of industries.

ISA has targeted the development of strategic alliances with a variety of industries for use of HPC and advanced visualisation including oil and gas, biotechnology, marine and defence, virtual engineering and digital content.

Research is conducted with universities and research organisations such as Murdoch University, Curtin University of Technology, Charles Darwin University, iVEC and the Western Australian Institute of Medical Research (WAIMR) as well as with technology firms such as Microsoft, IBM and Cisco.

ISA has worked with Woodside to support migration of seismic data, used to create an image of the earth structure to support oil and gas exploration, as part of oil and gas exploration and reserve definition efforts.

For example, around Australia, carbonate silts and sands create a challenge for engineering of foundation systems for offshore structures. In 2004, the piling that anchors the NWSV North Rankin 'A' platform to the seabed was improved to ensure it could withstand a 100 year return period cyclone. The remedial measures involved deep under-reamed bell foundations, developed with the assistance of the Centre for Offshore Foundation Systems at the

[34] Department of Foreign Affairs and Trade 2008, STARs database.

University of Western Australia. The measures demonstrated the application of links between new oil and gas infrastructure technologies, knowledge of the characteristics of sediments, and related engineering skills to provide feasible and commercially viable solutions.

The Centre for Offshore Foundation Systems has developed into a globally-renowned research and consulting facility with expertise in the sediment conditions found not only off the north-west coast of Australia, but also offshore India.

### 5.2.4 Collaboration and joint ventures

The NWSV created opportunity for domestic investment in research and development, which in turn, has resulted in joint ventures and collaboration between research bodies, government and international industry to provide support services to other major players in the oil and gas industry. These arrangements – particularly those with international partners – are an ideal channel for the development and diffusion of new technologies.[35]

For example, the Western Australia Research Alliance (Box 5), which provides technological research to NWSV operator Woodside as part of a $30 million joint venture agreement, also works internationally with collaborations with multinational corporations and universities such as Oxford University and the National University of Singapore.

Box 5 **WA Energy Research Alliance (WA:ERA)**

The WA:ERA was established in 2003 as a collaboration between the University of Western Australia, CSIRO and Curtin University of Technology in order to share knowledge, skills and facilities in order to conduct oil and gas industry research.

WA:ERA is located in Perth's Technology Park, conducting research with CCG Veritas, Chevron, Woodside and the WA Government. The alliance has three core research areas to target key technological challenges. These include gas technologies, facilities and subsurface technologies.

In 2004, Woodside signed a Joint Venture agreement for a five-year program with the WA:ERA worth up to $30 million.

[35] Clements K.W. and Greig R.A. 1994, op.cit., pp 92.

### 5.2.5 Structural change in the WA economy

The NWSV has had a significant impact on the economic structure of the Western Australian economy. It has underpinned the development of a fast growing and innovative oil and gas services industry. Many oil and gas services providers have expanded from their initial role supplying the NWSV, to supply other customers and diversify into new technologies and services. Clough, for example, had its first offshore oil and gas contract with the NWSV North Rankin A platform, and now provides oil and gas engineering and other project management services to the world (Box 6). This diversification and growth is driving a broadening and deepening of the Western Australian economy, leading to permanent structural change.

Box 6 **Clough**

Clough is a Perth based provider of oil and gas services, providing front-end engineering design, construction, installation, commissioning to operation, asset support and maintenance services.

Clough's initial oil and gas work commenced with the Barrow Island oil field development in the 1960s. Clough then expanded its oil and gas activities in the 1970s and 1980s, including through work on the NWSV North Rankin A platform – which was its first major offshore construction project.

It has since won oil and gas work in Indonesia, the North Sea, New Zealand, Thailand and the Gulf of Mexico, among other locations.

As a member of the Kellogg Joint Venture, Clough also worked on the NWSV's Train IV expansion project, and has worked on the front end engineering and design for Chevron's Gorgon project. Clough is currently working on the Pluto LNG jetty, and is providing engineering, procurement and module fabrication for the Devil Creek Development Project onshore domestic gas facility.

In providing these services Clough has formed partnerships, including with Kellogg Brown Root, JGC, and Hatch.

Source: WA Business News and www.clough.com.au

Other benefits of major technology investments arise through transfer of labour, from learning effects and from market development externalities. Improvements in the productivity of domestic firms occurs as a result of knowledge externalities through labour transfer when employees of the NWSV and its sub-contractors – who have gained new knowledge – transfer to a domestic firm. Knowledge transfers also occur as labour moves from technologically advanced overseas firms, including from NWSV participants and overseas suppliers, to the local industry.

Clements and Greig identified that personnel employed as service contractors, subcontractors, vendors and consultants under contract to Woodside were an important conduit for the transfer of new and advanced technologies.[36] For example, at the commencement of the LNG phase of the NWSV, the required technologies were possessed by international companies such as the Dutch organisation SIPM, Kellogg Overseas Corporation, and Japan Gas Corporation. Consequently, joint ventures where formed and personnel were transferred between the organisations to provide services to the NWSV. Western Australian personnel were seconded to overseas design offices, to be exposed to standards and procedures relevant to the NWSV. On returning to Australia, the new technologies were adopted domestically, and the related know-how subsequently diffused through the local engineering industry.

Industry development has also been enabled through learning effects when domestic firms have adopted knowledge by replicating new practices or by reverse engineering. The development of Geographe Enterprises (Box 3) is one example. These benefits also flow to other large oil and gas ventures, in Western Australia and interstate, with similar characteristics utilising technologies as used in the NSWV.

The formation of the thriving oil and gas service and technology hub in Perth, stimulated by the NWSV, has given Western Australia the capacity to provide innovative solutions to the oil and gas industry that are utilised in other ventures, including in complex minerals processing industries.

Benefits may also be gained from the development of new markets, as industry linkages become easier due to an initial opening up of these markets by the NWSV. Australia's world-leading reputation as a reliable supplier of LNG has been built by the NWSV and benefits new and future projects.

In the same manner that technology may become available to competitors in the same industry, technology transfer may also occur between technologically related sectors. Advancements adopted by the NSWV have been altered and adapted to other sectors, such as the mining sector, through the same channels as previously outlined – that is, through learning effects, transfer of labour, technology diffusion and so on.

There have also been significant benefits to domestic firms who supply products and services to the oil and gas industry. These benefits include improvements in productivity from economies of scale associated with a major enterprise such as the NWSV, leading to increased productivity as domestic

[36] Clements K.W. and Greig R.A. 1994, op.cit., pp 91.

suppliers become increasingly competitive to gain contracts, or as suppliers gain access to new technologies in order to meet the product specification.

Services to the NWSV include enterprises involved in providing drilling services, oil and gas field exploration services, other oil and gas field services, information technologies, asset development services, and asset management services. Additional to these direct services, the NWSV has also created opportunity for business development in areas such as capital equipment and infrastructure, and in support infrastructure, research and development, and services relating to human resources.