	Highest Risk in Each Risk Category			
Scenario	**Safety**	**Cost**	**Environment**	**Production**
1. PV-Wind with BMB Storage and Gas OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's released from gas combustion	Sudden gas supply interruption	CO2 and other GHG's released from gas combustion	Sudden gas supply interruption
2. PV-Wind with PHS and Gas OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's released from gas combustion	Cost blowout of PHS projects	Death of species due to flooding from PHS reservoirs	Sudden gas supply interruption
3. PV-Wind with PSH and Bio Fuel OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's released from combustion	Cost blowout of PHS projects	Death of species due to flooding from PHS reservoirs	Commercial scale bio fuels not a mature industry
4. PV-Wind with CST Storage and Bio Fuel OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's released from combustion	CST Cost Blowout	Loss of containment of bio fuels	Commercial scale bio fuels not a mature industry
5. PV-Wind with CST Storage and Bio Fuel co-firing and OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's released from combustion	CST Cost Blowout	Loss of containment of bio fuels	Commercial scale bio fuels not a mature industry
6. BAU Coal with Gas OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	CO2 and other GHG's release from combustion	Sudden gas supply interruption	CO2 and other GHG's release from combustion	Sudden gas supply interruption
7. Nuclear Fission with Gas OCGT	Inherent Risk	Inherent Risk	Inherent Risk	Inherent Risk
	Residual Risk	Residual Risk	Residual Risk	Residual Risk
	Management of radioactive waste.	Generation 4 design technology unproven.	Management of radioactive waste.	Generation 3 design technology limitations.
	Severe	High	Moderate	Low

Inherent Risk is the risk that an activity would pose if no controls or other mitigating factors were in place (the gross risk or risk before controls)

Residual Risk is the risk that remains after controls are taken into account (the net risk or risk after controls). Mitigations may reduce the consequences or likelihood or both together. Credit can only be taken for a lower residual risk while the mitigations remain in place and fully effective. Historically, mitigations (especially complex ones) tend to degrade over time and provide reduced risk reduction.

	Highest Risk in Each Risk Category			
Scenario	Safety	Cost	Environment	Production
1a. PV-Wind with BMB Storage and Gas OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from gas combustion	Inherent Risk Residual Risk Sudden gas supply interruption	Inherent Risk Residual Risk CO2 and other GHG's released from gas combustion	Inherent Risk Residual Risk Sudden gas supply interruption
1b. PV-Wind with BMB Storage and Bio Fuel OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from combustion	Inherent Risk Residual Risk Commercial scale bio fuels not a mature industry	Inherent Risk Residual Risk Loss of containment of bio fuels	Inherent Risk Residual Risk Commercial scale bio fuels not a mature industry
2a. PV-Wind with PHS and Gas OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from gas combustion	Inherent Risk Residual Risk Cost blowout of PHS projects	Inherent Risk Residual Risk Death of species due to flooding from PHS reservoirs	Inherent Risk Residual Risk Sudden gas supply interruption
2b. PV-Wind with PSH and Bio Fuel OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from combustion	Inherent Risk Residual Risk Cost blowout of PHS projects	Inherent Risk Residual Risk Death of species due to flooding from PHS reservoirs	Inherent Risk Residual Risk Commercial scale bio fuels not a mature industry
3. PV-Wind with CST Storage and Bio Fuel OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from combustion	Inherent Risk Residual Risk CST Cost Blowout	Inherent Risk Residual Risk Loss of containment of bio fuels	Inherent Risk Residual Risk Commercial scale bio fuels not a mature industry
4. PV-Wind with CST Storage and Bio Fuel co-firing and OCGT	Inherent Risk Residual Risk CO2 and other GHG's released from combustion	Inherent Risk Residual Risk CST Cost Blowout	Inherent Risk Residual Risk Loss of containment of bio fuels	Inherent Risk Residual Risk Commercial scale bio fuels not a mature industry
5. BAU Coal with Gas OCGT	Inherent Risk Residual Risk CO2 and other GHG's release from combustion	Inherent Risk Residual Risk Sudden gas supply interruption	Inherent Risk Residual Risk CO2 and other GHG's release from combustion	Inherent Risk Residual Risk Sudden gas supply interruption
6a. Nuclear Fission with Gas OCGT	Inherent Risk Residual Risk Management of radioactive waste.	Inherent Risk Residual Risk Generation 4 design technology unproven.	Inherent Risk Residual Risk Management of radioactive waste.	Inherent Risk Residual Risk Generation 3 design technology limitations.
6b. Nuclear Fission with Bio Fuel OCGT	Inherent Risk Residual Risk Management of radioactive waste.	Inherent Risk Residual Risk Generation 4 design technology unproven.	Inherent Risk Residual Risk Management of radioactive waste.	Inherent Risk Residual Risk Generation 3 design technology limitations.
7. All Gas	Inherent Risk Residual Risk CO2 and other GHG's released from gas combustion	Inherent Risk Residual Risk Gas price increases	Inherent Risk Residual Risk CO2 and other GHG's released from gas combustion	Inherent Risk Residual Risk Sudden gas supply interruption

Severe	High	Moderate	Low

Inherent Risk is the risk that an activity would pose if no controls or other mitigating factors were in place (the gross risk or risk before controls)

Residual Risk is the risk that remains after controls are taken into account (the net risk or risk after controls). Mitigations may reduce the consequences or likelihood or both together. Credit can only be taken for a lower residual risk while the mitigations remain in place and fully effective. Historically, mitigations (especially complex ones) tend to degrade over time and provide reduced risk reduction.

Scenario		Power Generation Capacity, MW								Storage power	Max. storage energy
		Wind	**Solar PV**	**Solar CST**	**Gas (OCGT)**	**Biomass (OCGT &/or Co-fired)**	**Coal**	**Nuclear**	**TOTAL**	**MW**	**MWh**
1a	**85% RE**: W-PV-BMB-gas OCGT	6,000	3,000	0	3,000	0	0	0	12,000	Battery 1600	8,000
1b	**100% RE:** W-PV-BMB-bio fuel OCGT	6,000	3,000	0	0	3,000	0	0	12,000	Battery 1600	8,000
2a	**91% RE:** W-PV-BMB-PHS - gas OCGT	6,000	3,000	0	3,000	0	0	0	12,000	Battery 1600 PHS 1000	8,000 42,000
2b	**100% RE**: W-PV-BMB-PHS - bio fuel OCGT	6,000	3,000	0	0	3,000	0	0	12,000	Battery 1600 PHS 1000	8,000 42,000
3	**100% RE:** W-PV-CSTMS with biomass co-fire -bio fuel OCGT	5,000	2,000	1,200	0	3,000	0	0	11,200	CST 1200	13,000
4	**100% RE:** W-PV-biomass -CST MS-bio fuel OCGT	5,000	2,000	1,200	0	2,900	0	0	11,100	CST 1200	22,000
5	**BAU**: Coal - gas	480	1,000	0	2,400	0	2,400	0	6,280	0	0
6a	**Nuclear** - gas OCGT	480	1,000	0	2,400	0	0	2,400	6,280	0	0
6b	**Nuclear** - bio fuel OCGT	480	1,000	0	0	2,400	0	2,400	6,280	0	0
7	**All Gas**	480	1,000	0	4,800	0	0	0	6,280	0	0

Notes

1. Existing installed capacity of wind and solar PV in 2016 is approx 480MW and 1000MW respectively. It is assumed no further installations occur.
2. Biol fuel may include gas, diesel and oil as suitable for efficient use in turbine generators. Gas turbines have been confirmed as capable of accepting liquid fuel in addition to gas. Produced only from new farms so base material sequesters C)2 initially.

LIKELIHOOD

					Historical	Unheard of in the world	Near miss has occurred once or twice in the world	Near miss has occurred many times in the world	Has occurred once or twice in the world	Has occurred many times in the world	Has occurred in Australia
					Frequency: (Continuous operation)	Once every 10,000 to 100,000 years in the world	Once every 1,000 to 10,000 years in the world	Once every 100 to 1,000 years in the world	Once every 10 to 100 years in the world	Once every 1 to 10 years in the world	More than once a year in the world or continuously
						1	**2**	**3**	**4**	**5**	**6**
People	**Cost**	**Environment**	**Production (single facility)**			**Remote**	**Highly Unlikely**	**Unlikely**	**Possible**	**Quite Likely**	**Likely**
Minor injury/illness. Restricted work case or lost work case < 4	>A$100K	Localised (immediate area) Temporary Impact	Minor delays or lowered capacity of some non core functions of a facility	**1**	**Slight**						176
Major injury/illness, Permanent or partial disability or Lost work case > 4 Days	A$100K to A$1M	Localised (<1km2) Short term (weeks) impact	Delay in availability of portions of a facility by > 1 year or <10% less capacity	**2**	**Minor**					180	192
Major injury/illness, Permanent or partial disability or Lost work case > 4 Days	A$1 to A$10M	Medium Scale (1 - 10km2) Short term (years) impact	Delay in availability of a whole facility by > 1 years or >10% less capacity	**3**	**Moderate**				182	195	
1 to 20 Fatalities (or permanent total Disabilities)	A$10 to A$100M	Medium Scale (1 - 10km2) Medium term (years) impact	Delay in availability of a whole facility by > 3 years or >25% less capacity	**4**	**Major**			182	196		
20 to 200 Fatalities (or permanent total Disabilities)	A$100M to A$1000M	Large Scale (10 - 100km2) Long term, decades impact	Delay in availability of a whole facility by > 5 years or >50% less capacity	**5**	**Massive**		180	195			
> 200 Fatalities (or permanent total Disabilities)	>A$1000M	V. Large / Regional Scale (>100km2) long term/ permanent impact	Total unavailability of a whole facility	**6**	**Catastrophic**	176	192				

CONSEQUENCE

General Basis

This risk analysis applies to the entire SWIS over a nominal 30-40 year period (typical life of an energy generation facility before significant upgrade or life extension work is required). Six scenarios are considered as detailed in the summary page. The context of the scenarios with a small gas use in the medium term until replaced with storage or other renewables has been included.
The intention is summarise at a high level, the key inherent and residual risks associated with each of the scenarios to support an indicative comparison between them. It is not intended to capture all risks associated with each scenario.

The risk matrix and methodology used is based on similar matrices and methodologies used in the energy, oil and gas, mining and other industrial sectors. It has been adapted to suit the range of risks for the SWIS in a world context. Use of a formal matrix allows some level of quantification of the risks to allow objective comparison and decision making.

In events that are inherently worldwide issues (ie CO2 emissions from coal and gas), consequence is considered as the SWIS proportion of the total. Ie the relative contribution from the SWIS if applied on a widespread scale.
This analysis focuses on the generation part of the SWIS. Network risks are considered to be similar between all scenarios.

Consequence

Consequence of a single occurrence of the identified event. Consequence is considered separately in terms of the criteria of people, cost, environment and production. Consequences for each of the criteria may vary considerably for the same event. For instance, an event may be extremely hazardous to personnel but have little effect on the environment.

People is the consequences to people either locally or remotely and includes both immediate and long term considerations.

Cost is the short and long term costs resulting from the event. This includes both direct and indirect costs to the project owner and also society in general that may not be borne by the project owner.
Environment includes the consequences to the environment either locally or remotely and includes both immediate and long term considerations, regardless of whether costs are attributed for remedial efforts.
Production is a measure of the delay to commencement of or reduction in productive output from a single facility over its lifetime.

Likelihood

Likelihood is a measure of how often the single event is expected to occur over the lifetime of the system being considered, in this case, the entire SWIS. Likelihood can be expressed using one of three methods: historical, frequency and probability, depending on the type of event and availability of data. Typically, historical is used for facility wide events where historical data is available. Probability is generally used when considering individual pieces of equipment or process activities so is not relevant to this SWIS wide analysis.
Historical provides an indicator of actual risk based on actual events. It is important to ensure that the events included here are for similar facilities and technologies. Some credit should be included for improvements implemented over time.

Frequency is typically used for operating plants that have event data available. Ie data on failure rates for a particular piece of equipment for which there may be 100 or more installed across the facility.

Risk

Risk is a combination of the consequence and likelihood with 4 levels defined:
- Red: Severe and generally considered as unacceptable
- Orange: High and generally considered as undesirable
- Yellow: Moderate and generally considered that mitigations should be applied to decrease the risk in accordance with ALARP principles (As Low as Reasonably Practicable)
- Green: Low and generally considered as acceptable

Inherent Risk is the risk that an activity would pose if no controls or other mitigating factors were in place (the gross risk or risk before controls)
Residual Risk is the risk that remains after controls are taken into account (the net risk or risk after controls). Mitigations may reduce the consequences or likelihood or both together. Credit can only be taken for a lower residual risk while the mitigations remain in place and fully effective. Historically, mitigations (especially complex ones) tend to degrade over time and provide reduced risk reduction.

Completing the Tables

For each of the scenarios, a details table has been set up. Each line captures the details for a single event and consequence type. A single event may therefore have up to four lines - one for each consequence type.
For each event/consequence type, an inherent consequence and likelihood should be selected and the basis noted in the associated columns.
Any mitigations should then be identified and documented with a residual consequence and likelihood allocated to reflect the reduced risk after mitigations.

Item	Issue	Description	Cause	Category	Consequence Description	Likelihood Description	Inherent Risk Rating: Consequence	Inherent Risk Rating: Likelihood	Inherent Risk Rating: Risk	Mitigation	Residual Risk Rating: Consequence	Residual Risk Rating: Likelihood	Residual Risk Rating: Risk	Comments and Notes
1	Death of birds from wind turbines	Wind turbine blades hit flying birds and injure or kill them	Birds not aware that turbines present a danger	Environment	Injured and dead birds in vicinity of wind turbines leading to drop in population	High likelihood that there will be a small number	2	3		Slower moving blades in current designs	1	2		Current generation turbines are slower moving so have smaller impact on birds and recent studies indicate that birds learn to avoid the blades after some exposure.
2A	Wind turbine noise pollution	Impact on local people	Very Low Frequency and audible noise in excess of safe human thresholds	Safety	Some physical and mental health issues in people living and working very close to turbines for extended periods	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and ill health is speculative and based on limited anecdotal evidence only. Yet to be proven
2B	Wind turbine noise pollution	Impact on local wildlife	Very Low Frequency and audible noise in excess of safe wildlife thresholds	Environment	Altered behaviour patterns and reduction in numbers in the vicinity of the turbine	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and local wildlife issues is speculative and based on limited anecdotal evidence only. Yet to be proven
3	Wind turbine visual pollution	Impact on local people and travellers who are disturbed by the visual presence of turbines	Inherent to size of turbines	Safety	Some small number of people may be disturbed by the scale and shape of wind turbines	Low as anecdotal evidence only	1	2		None required	1	2		
4	Productive land required for PV farms	Land reserved for PV and not available for other uses.	High density of PV panel placement and large area required to collect energy.	Environment	Low as productive land is not required for PV farms. Large areas of non productive land are available	Low as locations can be chosen	2	3		Choose land that is not used for other purposes or minimally degraded by use for PV farms and space out panels to reduce land impact	1	2		
5A	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Production	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		Gas, biomass and storage included in the scenario, so consequences and likelihood low
5B	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Cost	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		
6	Failure of wind and solar resources to provide sufficient energy in some years	Prolonged abnormal low wind and solar conditions;	Abnormal seasonal conditions; declining trend in wind and solar resources due to global warming	Production	Insufficient solar and wind generation would mean more fuelled generation would be needed to compensate for losses.	SIREN modelling of 8 years in WA shows < 10% variation. In the unlikely event that wind or solar resources decline within the 30 year plant life; more alternative technologies can be used when replacing generation	4	2		Include some over capacity as per current fossil fuel based grid and monitor conditions and implement additional capacity to offset declining trend if becomes apparent	2	2		
7	Wind and PV cost blowout	Wind and PV cost blowout	Unknowns in project design and construction or long term operations and maintenance	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Recent history of reducing costs.	Mature commercial technologies with good track record	2	2		None required	2	2		
8A	CO2 and other GHG's released from gas combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO2) is released during gas extraction and transmission	Environment	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Less likely than for All gas scenario as much smaller quantities providing time to replace with storage alternatives	2	4		Potentially carbon capture if technology can be proven, but not cost competitive and not available in timeframe required	1	3		Gas in this scenario is a medium term inclusion until prices for renewables and storage options become more cost effective. CO2 levels in this scenario approx. 10% of that in All Gas
8B	CO2 and other GHG's released from gas combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO2) is released during gas extraction and transmission	Safety	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Less likely than for All gas scenario as much smaller quantities providing time to replace with storage alternatives	2	4		Potentially carbon capture if technology can be proven, but not cost competitive and not available in timeframe required	1	3		Gas in this scenario is a medium term inclusion until prices for renewables and storage options become more cost effective. CO2 levels in this scenario approx. 10% of that in All Gas
9A	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Production	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		Diversify sources and improve production and maintenance practices	1	3		
9B	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		Diversify sources and improve production and maintenance practices	1	3		
10	Gas price increases	Increased worldwide use of gas for energy production will continue to drive price rises as supply slows	Increasing demand coupled with limited supplies. New gas fields increasing expensive to find and develop	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		limited options as a fossil fuel. Find new gas sources if available.	1	3		
11A	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy restrictions until new sources of energy are deployed.	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Production	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	3	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
11B	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy price increases as facilities become stranded and new sources need to deployed	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	3	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
12	Fugitive Emissions	Unplanned releases of methane and CO2 as part of gas production and transmission. Methane is a 20 times more potent GHG than CO2.	Many sources and there is often insufficient design, production and maintenance effort to save costs.	Environment	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	4		More stringent enforcement of emission reductions requirements in design, production and maintenance. Lower use of gas results in lower likelihood.	1	3		Gas in this scenario is a medium term inclusion until prices for renewables and storage options become more cost effective. CO2 levels in this scenario approx. 10% of that in All Gas
13	Variability of behind the meter storage	Behind the meter storage available to the network cannot be guaranteed to meet requirements	Behind the meter storage is not regulated by any central control system so can vary depending on consumer activities.	Production	Insufficient energy available to meet demand spikes but offset by availability of gas or biomass generation	Some common mode behaviours that can be predicted, otherwise statistically predictable due the wide base.	2	2		None required	2	2		

							Inherent Risk Rating				Residual Risk Rating			
Item	Issue	Description	Cause	Category	Consequence Description	Likelihood Description	Consequence	Likelihood	Risk	Mitigation	Consequence	Likelihood	Risk	Comments and Notes
1	Death of birds from wind turbines	Wind turbine blades hit flying birds and injure or kill them	Birds not aware that turbines present a danger	Environment	Injured and dead birds in vicinity of wind turbines leading to drop in population	High likelihood that there will be a small number	2	3		Slower moving blades in current designs	1	2		Current generation turbines are slower moving so have smaller impact on birds and recent studies indicate that birds learn to avoid the blades after some exposure.
2A	Wind turbine noise pollution	Impact on local people	Very Low Frequency and audible noise in excess of safe human thresholds	Safety	Some physical and mental health issues in people living and working very close to turbines for extended periods	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and ill health is speculative and based on limited anecdotal evidence only. Yet to be proven
2B	Wind turbine noise pollution	Impact on local wildlife	Very Low Frequency and audible noise in excess of safe wildlife thresholds	Environment	Altered behaviour patterns and reduction in numbers in the vicinity of the turbine	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and local wildlife issues is speculative and based on limited anecdotal evidence only. Yet to be proven
3	Wind turbine visual pollution	Impact on local people and travellers who are disturbed by the visual presence of turbines	Inherent to size of turbines	Safety	Some small number of people may be disturbed by the scale and shape of wind turbines	Low as anecdotal evidence only	1	2		None required	1	2		
4	Productive land required for PV farms	Land reserved for PV and not available for other uses.	High density of PV panel placement and large area required to collect energy.	Environment	Low as productive land is not required for PV farms. Large areas of non productive land are available	Low as locations can be chosen	2	3		Choose land that is not used for other purposes or minimally degraded by use for PV farms and space out panels to reduce land impact	1	2		
5A	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Production	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		Gas, biomass and storage included in the scenario, so consequences and likelihood low
5B	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Cost	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		
6	Failure of wind and solar resources to provide sufficient energy in some years	Prolonged abnormal low wind and solar conditions;	Abnormal seasonal conditions; declining trend in wind and solar resources due to global warming	Production	Insufficient solar and wind generation would mean more fuelled generation would be needed to compensate for losses.	SIREN modelling of 8 years in WA shows < 10% variation. In the unlikely event that wind or solar resources decline within the 30 year plant life; more alternative technologies can be used when replacing generation	4	2		Include some over capacity as per current fossil fuel based grid and monitor conditions and implement additional capacity to offset declining trend if becomes apparent	2	2		
7	Wind and PV cost blowout	Wind and PV cost blowout	Unknowns in project design and construction or long term operations and maintenance	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Recent history of reducing costs.	Mature commercial technologies with good track record	2	2		None required	2	2		
8A	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Stringent cost management structures, greater technical proving and prototyping.	2	4		
8B	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	2	4		Timeframe is a major consideration for deployment of bio fuels at utility scale due to the extended time required for growth of fuel feedstock.
9A	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Cost	Insufficient to meet demand leading to price increases and the need to find other sources	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
9B	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Production	Insufficient to meet demand leading to the need to find other sources to meet production requirements	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
10	Loss of containment of bio fuels	Spillage from tanks, pipelines etc.	Poor design and maintenance or accidents	Environment	Localised impact as no bulk reservoirs and production ongoing as required to meet demand with limited inventory	Possible based on historical precedent for fossil fuels when used in utility scale	1	4		Improved design and implementation of containment procedures and clean-up provisions in conjunction. As implemented currently in the fossil fuel industry.	1	3		
11A	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Safety	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels
11B	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Environment	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels

12A	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Environment	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
12B	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Production	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
13	Variability of behind the meter storage	Behind the meter storage available to the network cannot be guaranteed to meet requirements	Behind the meter storage is not regulated by any central control system so can vary depending on consumer activities.	Production	Insufficient energy available to meet demand spikes but offset by availability of gas or biomass generation	Some common mode behaviours that can be predicted, otherwise statistically predictable due the wide base.	2	2		None required	2	2		

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Item	Issue	Description	Cause	Category	Consequence Description	Likelihood Description	Consequence	Likelihood	Risk	Mitigation	Consequence	Likelihood	Risk	Comments and Notes
1	Death of birds from wind turbines	Wind turbine blades hit flying birds and injure or kill them	Birds not aware that turbines present a danger	Environment	Injured and dead birds in vicinity of wind turbines leading to drop in population	High likelihood that there will be a small number	2	3		Slower moving blades in current designs	1	2		Current generation turbines are slower moving so have smaller impact on birds and recent studies indicate that birds learn to avoid the blades after some exposure.
2A	Wind turbine noise pollution	Impact on local people	Very Low Frequency and audible noise in excess of safe human thresholds	Safety	Some physical and mental health issues in people living and working very close to turbines for extended periods	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and ill health is speculative and based on limited anecdotal evidence only. Yet to be proven
2B	Wind turbine noise pollution	Impact on local wildlife	Very Low Frequency and audible noise in excess of safe wildlife thresholds	Environment	Altered behaviour patterns and reduction in numbers in the vicinity of the turbine	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and local wildlife issues is speculative and based on limited anecdotal evidence only. Yet to be proven
3	Wind turbine visual pollution	Impact on local people and travellers who are disturbed by the visual presence of turbines	Inherent to size of turbines	Safety	Some small number of people may be disturbed by the scale and shape of wind turbines	Low as anecdotal evidence only	1	2		None required	1	2		
4	Productive land required for PV farms	Land reserved for PV and not available for other uses.	High density of PV panel placement and large area required to collect energy.	Environment	Low as productive land is not required for PV farms. Large areas of non productive land are available	Low as locations can be chosen	2	3		Choose land that is not used for other purposes or minimally degraded by use for PV farms and space out panels to reduce land impact	1	2		
5A	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Production	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		Gas, biomass and storage included in the scenario, so consequences and likelihood low
5B	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Cost	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		
6	Failure of wind and solar resources to provide sufficient energy in some years	Prolonged abnormal low wind and solar conditions;	Abnormal seasonal conditions; declining trend in wind and solar resources due to global warming	Production	Insufficient solar and wind generation would mean more fuelled generation would be needed to compensate for losses.	SIREN modelling of 8 years in WA shows < 10% variation. In the unlikely event that wind or solar resources decline within the 30 year plant life; more alternative technologies can be used when replacing generation	4	2		Include some over capacity as per current fossil fuel based grid and monitor conditions and implement additional capacity to offset declining trend if becomes apparent	2	2		
7	Wind and PV cost blowout	Wind and PV cost blowout	Unknowns in project design and construction or long term operations and maintenance	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Recent history of reducing costs.	Mature commercial technologies with good track record	2	2		None required	2	2		
8A	CO_2 and other GHG's released from gas combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO_2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO_2) is released during gas extraction and transmission	Environment	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Less likely than for All gas scenario as much smaller quantities providing time to replace with storage alternatives	2	4		Potentially carbon capture if technology can be proven, but not cost competitive and not available in timeframe required	1	3		Gas in this scenario is a medium term inclusion until prices for renewables and storage options become more cost effective. CO_2 levels in this scenario approx. 10% of that in All Gas
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9A	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Production	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		Diversify sources and improve production and maintenance practices	1	3		
9B	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		Diversify sources and improve production and maintenance practices	1	3		
10	Gas price increases	Increased worldwide use of gas for energy production will continue to drive price rises as supply slows	Increasing demand coupled with limited supplies. New gas fields increasing expensive to find and develop	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	5		Limited options as a fossil fuel. Find new gas sources if available.	1	4		
11A	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy restrictions until new sources of energy are deployed.	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Production	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	2	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
11B	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy price increases as facilities become stranded and new sources need to deployed	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Cost	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	2	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
12	Fugitive Emissions	Unplanned releases of methane and CO_2 as part of gas production and transmission. Methane is a 20 times more potent GHG than CO_2.	Many sources and there is often insufficient design, production and maintenance effort to save costs.	Environment	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	Same as for All Gas scenario	2	4		More stringent enforcement of emission reductions requirements in design, production and maintenance. Lower use of gas results in lower likelihood.	1	3		Gas in this scenario is a medium term inclusion until prices for renewables and storage options become more cost effective. CO_2 levels in this scenario approx. 10% of that in All Gas
13	Death of species due to flooding from PHS reservoirs	Death of all land species in area of water reservoirs	Land cleared and covered in water	Environment	Death of all land species in area of water reservoirs - approx. 10km2. Reservoirs located to minimise impact	Likelihood reduced if choose location carefully.	4	4		Locate in area where minimal impact on critical species	2	4		

14	Death of species due to salinity from PHS reservoirs	Addition of salts to the PHS reservoir land area	Seepage and spillages of salt water	Environment	Increased salt levels in water table and top soil leading to dieback of salt intolerant species	Reservoir is normally lined but some leakage is unavoidable. Likelihood reduced if choose location carefully.	3	4		Improved sealing of reservoir bed and increased monitoring	2	4		
15	Cost blowout of PHS projects	Proven technology but not implemented widely on large scale	Unknowns in project design and construction or long term operations and maintenance	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Can take advantage of existing projects that do exist and have been operating for long periods	4	4		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	3	3		
16	Negative effects on local aquatic species due to ocean salt levels increased	Negative effects on local aquatic species due to ocean salt levels increased	Pumping of high salinity water into ocean due to evaporation increasing upper reservoir salinity	Environment	Increased local salt levels leading to dieback of salt intolerant species in the area	Inherent to the technology. Reduced by careful selection of discharge area to minimise impact	4	4		Improved mixing and dispersion	3	3		

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5A	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Production	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		Gas, biomass and storage included in the scenario, so consequences and likelihood low
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8A	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Stringent cost management structures, greater technical proving and prototyping.	2	4		
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9A	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Cost	Insufficient to meet demand leading to price increases and the need to find other sources	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
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10	Loss of containment of bio fuels	Spillage from tanks, pipelines etc.	Poor design and maintenance or accidents	Environment	Localised impact as no bulk reservoirs and production ongoing as required to meet demand with limited inventory	Possible based on historical precedent for fossil fuels when used in utility scale	1	4		Improved design and implementation of containment procedures and clean-up provisions in conjunction. As implemented currently in the fossil fuel industry.	1	3		
11A	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Safety	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels
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12A	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Environment	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
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10	Loss of containment of bio fuels	Spillage from tanks, pipelines etc.	Poor design and maintenance or accidents	Environment	Localised impact as no bulk reservoirs and production ongoing as required to meet demand with limited inventory	Possible based on historical precedent for fossil fuels when used in utility scale	1	4		Improved design and implementation of containment procedures and clean-up provisions in conjunction. As implemented currently in the fossil fuel industry.	1	3		
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13	CST Cost Blowout	Project cost blowouts and higher than estimated operational costs	New technology with very limited operational experience to confirm lifecycle cost estimates	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Recent plants have had reasonable project cost management but not yet proven cost estimates for operations	4	4		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	3	3		Small part of overall scheme
14	Damage to local ecosystems from CST salt spillage	Damage to local ecosystems from CST salt spillage	High volumes of salt. Some spillage inevitable	Environment	Low consequences as salt is solid/liquid so not readily dissipated in a dry environment where CST plants to be located	Low as solid salt spills able to be managed easily	2	2		None required	2	2		
15	CST - adequacy of water supplies for thermal steam plant	Reliable high quality water supplies are required for steam thermal plant. Water in dry regions where CST plants are located is often limited and/or saline	CST plants are likely to require costly on-site desalination plants or long water supply pipelines	Cost	Water is crucial to the operation of CST plants. If there is major failure of the fresh water supply, rectification will be expensive and could result in many months of lost production	Moderate but low if mitigated by due diligence	4	4		Due diligence in proving designing and costing water supplies when selecting sites	3	2		

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1	Death of birds from wind turbines	Wind turbine blades hit flying birds and injure or kill them	Birds not aware that turbines present a danger	Environment	Injured and dead birds in vicinity of wind turbines leading to drop in population	High likelihood that there will be a small number	2	3		Slower moving blades in current designs	1	2		Current generation turbines are slower moving so have smaller impact on birds and recent studies indicate that birds learn to avoid the blades after some exposure.
2A	Wind turbine noise pollution	Impact on local people	Very Low Frequency and audible noise in excess of safe human thresholds	Safety	Some physical and mental health issues in people living and working very close to turbines for extended periods	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and ill health is speculative and based on limited anecdotal evidence only. Yet to be proven
2B	Wind turbine noise pollution	Impact on local wildlife	Very Low Frequency and audible noise in excess of safe wildlife thresholds	Environment	Altered behaviour patterns and reduction in numbers in the vicinity of the turbine	Low as connection not yet proven	2	1		None required	2	1		Link between wind turbines and local wildlife issues is speculative and based on limited anecdotal evidence only. Yet to be proven
3	Wind turbine visual pollution	Impact on local people and travellers who are disturbed by the visual presence of turbines	Inherent to size of turbines	Safety	Some small number of people may be disturbed by the scale and shape of wind turbines	Low as anecdotal evidence only	1	2		None required	1	2		
4	Productive land required for PV farms	Land reserved for PV and not available for other uses.	High density of PV panel placement and large area required to collect energy.	Environment	Low as productive land is not required for PV farms. Large areas of non productive land are available	Low as locations can be chosen	2	3		Choose land that is not used for other purposes or minimally degraded by use for PV farms and space out panels to reduce land impact	1	2		
5A	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Production	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		Gas, biomass and storage included in the scenario, so consequences and likelihood low
5B	Variability of wind and PV energy production	Amount of energy available can vary significantly from second to second, hour to hour, day to day and seasonally.	Wind strength and amount of sunlight vary from second to second up to seasonal cycles	Cost	Other forms of energy (gas and biomass) and energy storage required to ensure supply meets demand at all times. All included in this scenario.	Low as gas, biomass and storage included in the scenario	1	1		None required	1	1		
6	Failure of wind and solar resources to provide sufficient energy in some years	Prolonged abnormal low wind and solar conditions;	Abnormal seasonal conditions; declining trend in wind and solar resources due to global warming	Production	Insufficient solar and wind generation would mean more fuelled generation would be needed to compensate for losses.	SIREN modelling of 8 years in WA shows < 10% variation. In the unlikely event that wind or solar resources decline within the 30 year plant life; more alternative technologies can be used when replacing generation	4	2		Include some over capacity as per current fossil fuel based grid and monitor conditions and implement additional capacity to offset declining trend if becomes apparent	2	2		
7	Wind and PV cost blowout	Wind and PV cost blowout	Unknowns in project design and construction or long term operations and maintenance	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Recent history of reducing costs.	Mature commercial technologies with good track record	2	2		None required	2	2		
8A	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Stringent cost management structures, greater technical proving and prototyping.	2	4		
8B	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	2	4		Timeframe is a major consideration for deployment of bio fuels at utility scale due to the extended time required for growth of fuel feedstock.
9A	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Cost	Insufficient to meet demand leading to price increases and the need to find other sources	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
9B	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Production	Insufficient to meet demand leading to the need to find other sources to meet production requirements	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
10	Loss of containment of bio fuels	Spillage from tanks, pipelines etc.	Poor design and maintenance or accidents	Environment	Localised impact as no bulk reservoirs and production ongoing as required to meet demand with limited inventory	Possible based on historical precedent for fossil fuels when used in utility scale	1	4		Improved design and implementation of containment procedures and clean-up provisions in conjunction. As implemented currently in the fossil fuel industry.	1	3		
11A	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Safety	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels
11B	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Environment	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	3		CO2 footprint possibly at sustainable levels

12A	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Environment	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
12B	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Production	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
13	CST Cost Blowout	Project cost blowouts and higher than estimated operational costs	New technology with very limited operational experience to confirm lifecycle cost estimates	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Recent plants have had reasonable project cost management but not yet proven cost estimates for operations	4	4		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	3	3		Small part of overall scheme
14	Damage to local ecosystems from CST salt spillage	Damage to local ecosystems from CST salt spillage	High volumes of salt. Some spillage inevitable	Environment	Low consequences as salt is solid/liquid so not readily dissipated in a dry environment where CST plants to be located	Low as solid salt spills able to be managed easily	2	2		None required	2	2		
15	CST - adequacy of water supplies for thermal steam plant	Reliable high quality water supplies are required for steam thermal plant. Water in dry regions where CST plants are located is often limited and/or saline	CST plants are likely to require costly on-site desalination plants or long water supply pipelines	Cost	Water is crucial to the operation of CST plants. If there is major failure of the fresh water supply, rectification will be expensive and could result in many months of lost production	Moderate but low if mitigated by due diligence	4	4		Due diligence in proving designing and costing water supplies when selecting sites	3	2		

							Inherent Risk Rating				Residual Risk Rating			
Item	Issue	Description	Cause	Category	Consequence Description	Likelihood Description	Consequence	Likelihood	Risk	Mitigation	Consequence	Likelihood	Risk	Comments and Notes
1A	CO2 and other GHG's release from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO2) is released during gas extraction and transmission	Environment	Contribution to global warming causes negative impacts on worldwide health, food production, environment and low lying communities. Under COP agreement even small states will incur sanctions it they do not reduce per capita emissions.	Inherent to burning coal and natural gas for energy	6	6		Potentially carbon capture if technology can be proven, but not cost competitive and not available in timeframe required	6	6		
1B	CO2 and other GHG's release from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO2) is released during gas extraction and transmission	Safety	Contribution to global warming causes negative impacts on worldwide health, food production, environment and low lying communities. Under COP agreement even small states will incur sanctions it they do not reduce per capita emissions.	Inherent to burning natural gas for energy	6	6		Potentially carbon capture if technology can be proven, but not cost competitive and not available in timeframe required	6	6		
2A	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Production	Same as for All Gas scenario but less consequences as only a moderate part of the overall energy generation mix.	Same as for All Gas scenario	3	6		Diversify sources and improve production and maintenance practices	2	6		More gas burnt than for wind-PV so consequences slightly higher
2B	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Cost	Same as for All Gas scenario but less consequences as only a moderate part of the overall energy generation mix.	Same as for All Gas scenario	3	6		Diversify sources and improve production and maintenance practices	2	6		
3	Gas price increases	Increased worldwide use of gas for energy production will continue to drive price rises as supply slows	Increasing demand coupled with limited supplies. New gas fields increasing expensive to find and develop	Cost	Same as for All Gas scenario but less consequences as only a moderate part of the overall energy generation mix.	Same as for All Gas scenario	3	5		limited options as a fossil fuel. Find new gas sources if available.	2	5		
4A	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy restrictions until new sources of energy are deployed.	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Production	Same as for All Gas scenario but less consequences as only a moderate part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	3	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
4B	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy price increases as facilities become stranded and new sources need to deployed	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Cost	Same as for All Gas scenario but less consequences as only a moderate part of the overall energy generation mix.	Same as for All Gas scenario but less consequences as only a small part of the overall energy generation mix.	3	2		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	2	2		
5	Fugitive Emissions	Unplanned releases of methane and CO2 as part of gas production and transmission. Methane is a 20 times more potent GHG than CO2.	Many sources and there is often insufficient design, production and maintenance effort to save costs.	Environment	Similar to All Gas scenario but less consequences . 'Gassy' coal mines are a major source of methane emissions	Same as for All Gas scenario	3	6		More stringent enforcement of emission reductions requirements in design, production and maintenance. Almost impossible to eradicate, so can only reduce volume of emissions.	2	6		
6A	Deterioration of coal quality	Coal quality deterioration involving lower calorific value and higher emissions	Best coal reserves have already been consumed	Environment	Effect of making 1A worse	Highly likely as best reserves nearing exhaustion	6	6		Find new high quality reserves - considered unlikely	5	5		Best quality coal has already been mined and used. Remaining coal will have a lower thermal efficiency and higher emissions
7	Deaths and negative health impacts form air and water pollution, mining accidents	There are many deaths every year from mine accidents. Negative health effects mainly air pollution heavy metal (mercury) pollution of water resources cause illness and shortened life	Coal combustions cause sulphur and particulate pollution. Fly ash pollutes waterways. Poor practices due to cost cutting cause accidental deaths in coal mines	Safety	Externalized' cost of deaths and hospital care is borne by other tax payers, not coal corporations	Some mines/ power plants much worse than average but none can avoid all impacts	5	6		Scrubbers on power plants; adopt mining best design and safety practices	3	4		Some inherently dangerous mines are not possible to make safe and should be closed

Item	Issue	Description	Cause	Category	Consequence Description	Likelihood Description	Inherent Risk Rating: Consequence	Inherent Risk Rating: Likelihood	Inherent Risk Rating: Risk	Mitigation	Residual Risk Rating: Consequence	Residual Risk Rating: Likelihood	Residual Risk Rating: Risk	Comments and Notes
1A	Major release of radioactive contamination	Loss of containment leading to release of radioactive material into surrounding land or water, including populated or farming areas.	Natural disaster beyond design basis, operational accident, equipment failure as per prior near misses and events.	Safety	Deaths and debilitation due to brief exposure to high levels of radioactive material or longer term exposure to low levels in direct environment or food chain.	Historical basis - number of near misses and failures with documented catastrophic releases.	6	5		Mitigate consequences by locating in unpopulated areas. Probability of occurrence can be reduced by two orders of magnitude by use of complex active safeguarding systems.	5	3		Examples such as Three Mile Island, Chernobyl, Fukashima. Dependant on continuous performance of safeguarding systems. All safeguarding systems fail at times. Complex active system are more prone to failure due to gradual deterioration over time.
1B	Major release of radioactive contamination	Loss of containment leading to release of radioactive material into surrounding land or water, including populated or farming areas.	Natural disaster beyond design basis, operational accident, equipment failure as per prior near misses and events.	Environment	Long term contamination of environment over hundreds of km2 for an extended time.	Historical basis - number of near misses and failures with documented catastrophic releases.	6	5		Unable to mitigate consequences with available technology and knowledge. Probability of occurrence can be reduced by two orders of magnitude by use of complex active safeguarding systems.	6	3		Examples such as Three Mile Island, Chernobyl, Fukashima. Dependant on continuous performance of safeguarding systems. All safeguarding systems fail at times. Complex active system are more prone to failure due to gradual deterioration over time.
2A	Generation 3 design technology limitations.	Gen 3 technology is proven but has been demonstrated to be complex with fundamental limitations and long project delays.	Inherent limitations with the technology.	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase.	Historical basis - large number of delayed projects and facilities that have had extended down to address issues or have been shutdown prematurely.	6	5		Stringent cost management structures, greater technical proving over 10 years to determine age related issues	5	2		Numerous accidents and loss of production due to failures in Generation 3 plants.
2B	Generation 3 design technology limitations.	Gen 3 technology is proven but has been demonstrated to be deficient.	Inherent limitations with the technology.	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Historical basis - large number of large cost over-runs in all phases of projects including decommissioning.	6	5		Stringent cost management structures, greater technical proving and prototyping.	5	3		The industry has a history of extensive cost blow outs. New plants currently being built are experiencing the same levels of cost blowouts.
3A	Generation 4 design technology unproven.	New generation 4 designs are incomplete and untested in large scale commercial applications.	Inherent to new technology still early in its lifecycle.	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase.	Probability - technology not expected to be mature for 10 years plus (after extensive prototyping and commercial scale proving). Historically early adoption now would suffer major issues as problems are resolved on the run	6	6		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	5	4		
3B	Generation 4 design technology unproven.	New generation 4 designs are incomplete and untested in large scale commercial applications.	Inherent to new technology still early in its lifecycle.	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Probability - technology not expected to be mature for 10 years plus (after extensive prototyping and commercial scale proving). Historically early adoption now would suffer major issues as problems are resolved on the run	6	6		Extensive modelling and prototype testing	5	4		
4A	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Safety	Deaths and debilitation due to brief exposure to high levels of radioactive material or longer term exposure to low levels in direct environment or food chain.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		Long term storage and management solutions have been actively researched for 50 years without success to date.
4B	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Environment	Long term contamination of environment over hundreds of km2 for an extended time.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		
4C	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Cost	Costs associated with clean up and containment of releases. Medical costs of treatment for those affected by the releases.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		
5	Fugitive Emissions	Unplanned releases of methane and CO2 as part of gas production and transmission. Methane is a 20 times more potent GHG than CO2.	Many sources and there is often insufficient design, production and maintenance effort to save costs.	Environment	Contribution to global warming and consequent impact on worldwide environment. Consequences not as high as for CO2 from primary combustion, but still significant.	Normal practice	5	6		More stringent enforcement of emission reductions requirements in design, production and maintenance. Almost impossible to eradicate, so can only reduce volume of emissions.	3	5		Could argue that even though less gas burnt per year than all gas, consequence is the same but will just take longer.

							Inherent Risk Rating				Residual Risk Rating			
Item	**Issue**	**Description**	**Cause**	**Category**	**Consequence Description**	**Likelihood Description**	**Consequence**	**Likelihood**	**Risk**	**Mitigation**	**Consequence**	**Likelihood**	**Risk**	**Comments and Notes**
1A	Major release of radioactive contamination	Loss of containment leading to release of radioactive material into surrounding land or water, including populated or farming areas.	Natural disaster beyond design basis, operational accident, equipment failure as per prior near misses and events.	Safety	Deaths and debilitation due to brief exposure to high levels of radioactive material or longer term exposure to low levels in direct environment or food chain.	Historical basis - number of near misses and failures with documented catastrophic releases.	6	5		Mitigate consequences by locating in unpopulated areas. Probability of occurrence can be reduced by two orders of magnitude by use of complex active safeguarding systems.	5	3		Examples such as Three Mile Island, Chernobyl, Fukashima. Dependant on continuous performance of safeguarding systems. All safeguarding systems fail at times. Complex active system are more prone to failure due to gradual deterioration over time.
1B	Major release of radioactive contamination	Loss of containment leading to release of radioactive material into surrounding land or water, including populated or farming areas.	Natural disaster beyond design basis, operational accident, equipment failure as per prior near misses and events.	Environment	Long term contamination of environment over hundreds of km2 for an extended time.	Historical basis - number of near misses and failures with documented catastrophic releases.	6	5		Unable to mitigate consequences with available technology and knowledge. Probability of occurrence can be reduced by two orders of magnitude by use of complex active safeguarding systems.	6	3		Examples such as Three Mile Island, Chernobyl, Fukashima. Dependant on continuous performance of safeguarding systems. All safeguarding systems fail at times. Complex active system are more prone to failure due to gradual deterioration over time.
2A	Generation 3 design technology limitations.	Gen 3 technology is proven but has been demonstrated to be complex with fundamental limitations and long project delays.	Inherent limitations with the technology.	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase.	Historical basis - large number of delayed projects and facilities that have had extended down to address issues or have been shutdown prematurely.	6	5		Stringent cost management structures, greater technical proving over 10 years to determine age related issues	5	2		Numerous accidents and loss of production due to failures in Generation 3 plants.
2B	Generation 3 design technology limitations.	Gen 3 technology is proven but has been demonstrated to be deficient.	Inherent limitations with the technology.	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Historical basis - large number of large cost over-runs in all phases of projects including decommissioning.	6	5		Stringent cost management structures, greater technical proving and prototyping.	5	3		The industry has a history of extensive cost blow outs. New plants currently being built are experiencing the same levels of cost blowouts.
3A	Generation 4 design technology unproven.	New generation 4 designs are incomplete and untested in large scale commercial applications.	Inherent to new technology still early in its lifecycle.	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase.	Probability - technology not expected to be mature for 10 years plus (after extensive prototyping and commercial scale proving). Historically early adoption now would suffer major issues as problems are resolved on the run	6	6		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	5	4		
3B	Generation 4 design technology unproven.	New generation 4 designs are incomplete and untested in large scale commercial applications.	Inherent to new technology still early in its lifecycle.	Cost	Unbudgeted costs for design, construction, operation and decommissioning.	Probability - technology not expected to be mature for 10 years plus (after extensive prototyping and commercial scale proving). Historically early adoption now would suffer major issues as problems are resolved on the run	6	6		Extensive modelling and prototype testing	5	4		
4A	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Safety	Deaths and debilitation due to brief exposure to high levels of radioactive material or longer term exposure to low levels in direct environment or food chain.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		Long term storage and management solutions have been actively researched for 50 years without success to date.
4B	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Environment	Long term contamination of environment over hundreds of km2 for an extended time.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		
4C	Management of radioactive waste.	An acceptable solution for long term management of highly radioactive waste has not yet been determined. Storage remains short term to date and for the foreseeable future.	Techniques that are robust and secure for the required long time intervals are not yet available or sufficiently proven.	Cost	Costs associated with clean up and containment of releases. Medical costs of treatment for those affected by the releases.	Low level of releases from short term storage currently being experienced each year. Long duration of danger (ten's of thousands of years) indicates an extensive overall total release.	6	6		No known method to mitigate consequences. Develop long term management solution and demonstrate security for the required long timeframes required. Probability of this not considered high due to ongoing failure to date.	6	5		
5A	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Cost	Unbudgeted costs for design, construction, operation and decommissioning. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Stringent cost management structures, greater technical proving and prototyping.	2	4		
5B	Commercial scale bio fuels not a mature industry	Commercial processes are available and being deployed but not at utility scale	Emerging industry	Production	Unplanned delays in design, construction and commissioning with extended production shutdowns to resolve issues during the production phase. Limited consequence as evolution of existing process required, not new processes.	Almost certain as part of utility scale commercialisation.	3	5		Extensive modelling and prototype testing. Stringent cost management structures, greater technical proving over 10 years to determine age related issues	2	4		Timeframe is a major consideration for deployment of bio fuels at utility scale due to the extended time required for growth of fuel feedstock.
6A	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Cost	Insufficient to meet demand leading to price increases and the need to find other sources	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		
6B	Resource Scarcity	Insufficient arable and semi arable land to grow feedstock for bio fuel production	Large areas are required that cannot be used for other purposes (or at least very limited)	Production	Insufficient to meet demand leading to the need to find other sources to meet production requirements	Sufficient suitable semi arable land is available for native type species that can be used for bio fuels	4	1		Source additional resources and factor in stockpiling	3	1		

7	Loss of containment of bio fuels	Spillage from tanks, pipelines etc.	Poor design and maintenance or accidents	Environment	Localised impact as no bulk reservoirs and production ongoing as required to meet demand with limited inventory	Possible based on historical precedent for fossil fuels when used in utility scale	1	4		Improved design and implementation of containment procedures and clean-up provisions in conjunction. As implemented currently in the fossil fuel industry.	1	3		
8A	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Safety	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels
8B	CO2 and other GHG's released from combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	Releases from supplementary sources such as transport and imbedded energy in plant and equipment. Base carbon cycle of fuel itself is neutral as Carbon sequestered to start.	Environment	Same as for all gas scenario except far smaller scale.	Inherent to supplemental energy use.	1	3		Use renewable energy sources for supplemental energy use.	1	2		CO2 footprint possibly at sustainable levels
9A	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Environment	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		
9B	Sustainability of bio fuel production	Degradation of farm resource as nutrients are lost when the bio fuel is combusted. Most returned but some lost in emissions.	Nutrient cycle from farm, to processing plant to generator and back to farm (of residues will not be 100% efficient and some nutrients will be lost.	Production	Degradation and eventual loss of farmland resource unless nutrients are supplemented from external sources. Much lower impact than current farming practices.	Inherent to system	1	4		Supplement nutrients with sustainable external sources which can be feasible due to low quantities required and low losses in the system.	1	1		

							Inherent Risk Rating				Residual Risk Rating			
Item	**Issue**	**Description**	**Cause**	**Category**	**Consequence Description**	**Likelihood Description**	**Consequence**	**Likelihood**	**Risk**	**Mitigation**	**Consequence**	**Likelihood**	**Risk**	**Comments and Notes**
1A	CO_2 and other GHG's released from gas combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO_2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO_2) is released during gas extraction and transmission	Environment	Contribution to global warming causes negative impacts on worldwide health, food production,environment and low lying communities. Under COP agreement even small states will incur sanctions it they do not reduce per capita emissions.	Inherent to burning natural gas for energy	6	6		Potentially carbon capture if technology can be proven, but not cost competetive and not available in timeframe required	6	6		Consequence set at maximum even though less CO_2 intensive than coal as emissions still significantly above those that will produce catastrophic climate change if deployed widely as a primary energy option.
1B	CO_2 and other GHG's released from gas combustion	Increasing concentration of atmospheric greenhouse gases (GHG's) cause global warming that takes many decades to reverse	CO_2, nitrous oxide and ozone greenhouse gases are products of combusting gas; methane (20 times stronger GHG than CO_2) is released during gas extraction and transmission	Safety	Contribution to global warming causes negative impacts on worldwide health, food production,environment and low lying communities. Under COP agreement even small states will incur sanctions it they do not reduce per capita emissions.	Inherent to burning natural gas for energy	6	6		Potentially carbon capture if technology can be proven, but not cost competetive and not available in timeframe required	6	6		Consequence set at maximum even though less CO_2 intensive than coal as emissions still significantly above those that will produce catastrophic climate change if deployed widely as a primary energy option.
2A	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation. As all gas, no diversity.	Disruption to one of a small number of gas supply routes	Production	Reduced energy available for an extended period.	Has happened.	5	6		Diversify sources and improve production and maintenance practices	4	4		Happened with the Varanus island explosion and extended reduced supply. Impact less then as gas was not the primary energy fuel.
2B	Sudden gas supply interruption	Loss of a significant percentage of gas supply required for energy generation.	Disruption to one of a small number of gas supply routes	Cost	Significant reduction on industry, commercial and public activities. Expedited repairs required at premium cost.	Has happened.	4	6		Diversify sources and improve production and maintenance practices	3	4		Happened with the Varanus island explosion and extended reduced supply. Impact less then as gas was not the primary energy fuel.
3	Gas price increases	Increased worldwide use of gas for energy production will continue to drive price rises as supply slows	Increasing demand coupled with limited supplies. New gas fields increasing expensive to find and develop	Cost	Higher energy costs	Already happening	5	5		limited options as a fossil fuel. Find new gas sources if available.	4	4		Coal seam and shale gas may slow the price increase for a short period, but would struggle to satisfy demand if all energy was derived from gas.
4A	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy restrictions until new sources of energy are deployed.	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Production	Significant reduction on industry, commercial and public activities.	Has happened repeatedly throughout the world due to political issues	5	3		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	3	2		Typically 3-5 year lag to commission new power plant from recognition of requirement. Gas shortage could manifest in a far shorter time than this.
4B	Depletion of gas reserves leading to loss of supply	Gas shortages with consequent energy price increases as facilities become stranded and new sources need to deployed	Increased worldwide use of gas for energy production coupled with limited supply leading to shortages as supplies are depleted.	Cost	Higher energy costs	Has happened repeatedly throughout the world due to political issues	5	3		Stringent monitoring of gas supply and demand and timely introduction of new energy generation facilities.	3	2		Typically 3-5 year lag to commission new power plant from recognition of requirement. Gas shortage could manifest in a far shorter time than this.
5	Fugitive Emissions	Unplanned releases of methane and CO_2 as part of gas production and transmission. Methane is a 20 times more potent GHG than CO_2.	Many sources and there is often insufficient design, production and maintenance effort to save costs.	Environment	Contribution to global warming and consequent impact on worldwide environment. Consequences not as high as for CO_2 from primary combustion, but still significant.	Normal practice	5	6		More stringent enforcement of emission reductions requirements in design, production and maintenance. Almost impossible to eradicate, so can only reduce volume of emissions.	3	5		Coal seam and shale gas with the large number of cheap wells has a higher fugitive emissions risk than conventional wells.