INCREASING CLIMATE RESILIENCE IN THE NORTHERN TERRITORY: HARNESSING OPPORTUNITIES AND MITIGATING CLIMATE RISK

A RESPONSE TO THE NORTHERN TERRITORY GOVERNMENT'S CLIMATE CHANGE DISCUSSION PAPER

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OVERVIEW

In October, 2018, the Northern Territory Government (NTG) released the *Climate Change Discussion Paper*[1]. The *Discussion Paper* details the Northern Territory's (NT) greenhouse gas (GHG) emission trajectory; outlines the projected climate change impacts; and highlights action already being undertaken in the NT to mitigate and adapt to climate change. In addition, potential opportunities associated with climate action are advanced.

The NTG has requested feedback to inform the development of a climate change strategy and action plan. This report aims to respond to the *Climate Change Discussion Paper*.

This research was conducted throughout a three-month fellowship funded by the German Federal Ministry of Education and Research (Green Talent Award for High Potentials in Sustainable Development, 2017). The fellowship was undertaken at the NewClimate Institute for Climate Policy and Global Sustainability in Germany; a leading not-for-profit climate change research institute.

All views expressed in this report are the authors own.

Thank you to all of the experts, both in Australia and in Europe, who provided valuable advice and feedback to inform the development of this report.

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Ellin has advised governments; the private sector; and not-for-profits – including the National Government of Vietnam; the City of Paris; and the UK water sector – on increasing climate resilience.

[1] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory*.

SUMMARY

The NTG's response to climate change must reflect the level of risk. Climate change poses *severe* risks to all Territorians – loss of life; irreparable damage to human and natural systems; and significant economic costs. The response required is unprecedented.

It will require far-reaching and rapid changes within all sectors. Economic growth can no longer be coupled with an increase in GHG emissions. To remain within a 'safe' climate system boundary, a deep reduction in global net human-caused GHG emissions must be realised.

For the NTG to mitigate dangerous climate risk, a comprehensive evidence-based climate change policy must be implemented along with an emissions reduction target of net zero emissions by 2050.

The NT is being left behind the curve - Queensland; New South Wales; Victoria; the Australian Capital Territory; South Australia; and Tasmania have net zero emission targets and are realising the opportunities associated with a low-carbon transition. Compared to a business as usual pathway, bold climate action at a global scale could yield a *direct economic gain of USD26 trillion by 2030* – and this is a conservative estimate[2].

If strategically designed and implemented – with a people-centred focus – a low-carbon transition will deliver clear benefits to people; ecosystems; and economies. Importantly; the technology and expertise required for this transition are available *today.*

When compared to the costs posed by not taking action, there is no other avenue *but* to implement wide-reaching climate change mitigation and adaptation measures within the NT.

The NTG must engage all sectors across the Territory to achieve the scale of change required. There is a considerable level of expertise within the NT to meet this challenge.

This report serves to highlight examples of how the NTG can respond to climate risk and simultaneously realise the significant benefits in doing so. It is divided into examples of mitigation opportunities; risks not yet considered; and adaptation. The report offers recommendations, summarised below.

It must be noted, this report does not provide a comprehensive overview of the mitigation opportunities available. It instead aims to highlight examples of potential avenues the NTG can pursue. Mitigation of GHG emissions *must* be realised across all sectors.

There is a short window of time to act. It is crucial pragmatic and evidence-based political decisions are made *now* to ensure the best outcomes for Territorians.

[2] The Global Commission on the Economy and Climate, *Unlocking the Inclusive Growth Story of the 21st Century*.

REPORT OUTLINE

SECTION 1: STATE OF THE EVIDENCE

CLIMATE CHANGE SCIENCE OVERVIEW (*Page 4)*

1. The risks posed to Territorians are severe and need to be mitigated, as a matter of urgency

SECTION 2: IMPLEMENTING AN EVIDENCE-BASED POLICY

TRANSITION TO A LOW-CARBON ECONOMY (*Page 5)*

1. Develop a comprehensive climate change policy to mitigate climate risk

2. Establish an independent Climate Resilience Advisory Committee – comprised of experts and relevant stakeholders – to inform the low-carbon transition process

EMISSIONS REDUCTION TARGET (*Page 6)*

1. Legislate a science-based emissions reduction target of net zero by 2050. Include interim targets and sector-specific targets

SECTION 3: MITIGATION OPPORTUNITIES FOR THE NORTHERN TERRITORY

MAXIMISE RENEWABLE ENERGY GENERATION (*Pages 7-8)*

1. Set the post-2030 (maximising) renewable energy target, including interim targets, and begin the transition process

2. Determine the potential for different renewable energy technologies to contribute to the NT's future energy mix

HARNESS NEW ECONOMIC OPPORTUNITIES (RENEWABLE ENERGY) (*Pages 9-11)*

1. Investigate potential pathways for the NT to become a net energy exporter

2. Determine the feasibility of attracting new industries to the NT with the incentive of inexpensive, clean, electricity

3. Explore the potential for the NT to become a world-leading research hub for renewable energy technology

4. Investigate the feasibility of establishing a renewable hydrogen industry in the NT

NATURAL GAS: NOT A BRIDGING FUEL FOR THE TRANSITION TO RENEWABLES (*Pages 12-13)*

1. Natural gas should *not* be advanced as a low-carbon bridging fuel for the transition to renewables

2. Economic modelling; decarbonisation; and climate risk must be integrated into the decision-making process when determining the NT's development pathway

ENERGY EFFECIENCY IN BUILDINGS (*Page 14)*

1. Undertake energy retrofits across the Territory's building stock to optimise energy savings. Investigate complementary strategies to increase energy efficiency (e.g. demand management).

2. Mandate energy efficiency building codes to maximise emission reductions and cost savings. Ensure these are consistently updated to reflect technological advancements

3. Establish the NT as a hub for climate resilient and sustainable design

SECTION 4: RISKS NOT TAKEN INTO CONSIDERATION

STRANDED FOSSIL FUEL ASSETS (*Page 15)*

1. The NTG needs to factor the global low-carbon transition - and the subsequent risk of stranded fossil fuel assets - into government decision-making processes

RISK OF LITIGATION (*Page 16)*

1. Take legal duty of care (tort law) and human rights into consideration when developing the NTG's response to climate change

SECTION 5: ADAPTATION

CLIMATE RISK ASSESSMENT AND ADAPTATION STRATEGY (*Pages 17-18)*

1. As a matter of urgency, climate change risks for the Northern Territory need to be comprehensively investigated and determined (climate risk assessment)

2. An adaptation strategy then needs to be developed, taking into account both short- and long-term climate risks and differentiated impacts

CROSS-SECTORAL ENGAGEMENT (*Page 19)*

1. Implement evidence-based mechanisms to engage all Territorians in building climate resilience

SECTION 1: STATE OF THE EVIDENCE

To increase climate resilience, rapid, far-reaching, and deep reductions in greenhouse gas (GHG) emissions are required (net zero carbon emissions by 2050).

There is scientific consensus: greenhouse gas emissions need to decline rapidly to net zero[3]. *Net zero* is achieved when more GHG emissions are stored or sequestered than are released to the atmosphere[4].

This is consistent with the Paris Agreement science-based target; ratified by 197 countries, including Australia: Limit global warming to less than 2ºC and pursue efforts to limit warming to 1.5 ºC (above pre-industrial levels)[5]. This target was selected as within this threshold, the climate system is *likely* to remain in a habitable and stable state[6].

Warming at 1.5 ºC is not considered 'safe' for most nations; communities; ecosystems; and sectors and poses significant risks to natural and human systems (compared to current warming of 1ºC)[7].

The *IPCC Special Report on Global Warming of 1.5 ºC*[8], released on 8 October, 2018 (3 days after the *NTG Climate Change Discussion Paper*) determined the feasibility of limiting warming to 1.5 ºC. The report synthesised the best available scientific evidence; citing more than 6,000 scientific references. Thousands of expert and government reviewers contributed to the process[9].

The *IPCC Special Report* determined limiting global warming to 1.5 ºC would require rapid and far-reaching transitions in land; energy; industry; buildings; transport and cities. All sectors need to decarbonise.

Global net human-caused emissions of the carbon dioxide need to fall by approximately 45% from 2010 levels by 2030, reaching net zero by around 2050. This would require wide-sweeping and unprecedented changes in all aspects of society, with clear benefits to people and ecosystems[10].

While unprecedented in scale, this transition is possible. The technology and expertise to achieve this transition are available *today*. If this transition is strategically executed, significant co-benefits can be realised. However, the longer deep cuts in emissions are delayed, the more costly and difficult it will become, and the higher the subsequent climate risks. Unless rapid and deep emissions reductions are realised, the 1.5 ºC carbon budget threshold could be passed in *as little as 15 years*[11].

RECOMMENDATION

1. The risks posed to Territorians are *severe* and need to be mitigated, as a matter of urgency

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[3] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*; Pachauri et al., *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Steffen et al., "Trajectories of the Earth System in the Anthropocene."

[4] Metz, *Climate Change 2007: Mitigation: Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

[5] UNFCCC, *Paris Agreement Article 2(1)(A)*.

[6] Rockström et al., "A Safe Operating Space for Humanity."; Steffen et al., "Trajectories of the Earth System in the Anthropocene"; Lenton, "Early Warning of Climate Tipping Points."

[7] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*.

[8] Ibid.

[9] Intergovernmental Panel on Climate Change (IPCC), "IPCC Press Release: Summary for Policymakers of IPCC Special Report on Global Warming of 1.5ºC Approved by Governments."

[10] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*.

[11] Ibid.

SECTION 2: IMPLEMENTING AN EVIDENCE-BASED POLICY

TRANSITION TO A LOW-CARBON ECONOMY (DECARBONISATION)

The Northern Territory must transition to a low-carbon economy (and rapidly). Significant opportunities can be realised if the transition is effectively managed.

The *Discussion Paper* states the Territory needs to play its role in international and national efforts to reduce emissions and adapt to the impacts of our changing climate[12]. Australia is a developed nation, and as a developed nation, we have the capacity to commit to deep emissions reductions[13]. To stay within a 'safe operating space for humanity'[14], economic growth needs to be decoupled from carbon emissions[15]. Economic growth is achievable without high greenhouse emissions[16]. If effectively planned and implemented, climate solutions can deliver significant economic opportunities. Bold climate action could yield a direct economic gain of USD26 trillion through to 2030 compared with business as usual. This is likely to be a conservative estimate[17].

Lower risk. The lower the cumulative greenhouse gas emissions, the lower the risks and the associated costs – in terms of lives; social disruption; infrastructural damage; economic costs; and damage to the natural systems Territorians rely on. The current costs of weather-related risks are already significant. In 2017, the economic costs of extreme weather events in the NT was *$1.3 billion*. This figure does *not* incorporate the economic costs of heat waves or other climate-related hazards[18]. Extreme weather events are projected to intensify in the NT as global warming increases[19].

Economic risks of not decarbonising. There are significant risks posed for emissions-intensive resource-based economies as the world decarbonises (by 2050, all fossil fuels – including natural gas – must be phased out or compensated for)[20]. Risks include stranded assets and the implementation of mandatory stringent targets to lower emissions. In October, 2018, New York's Attorney General sued Exxon Mobil, following three years of extensive investigation. It claimed that Exxon Mobil defrauded shareholders by downplaying the risks of climate change to its business, namely, that stringent regulations to reduce greenhouse gas emissions would *inevitably be required*[21].

RECOMMENDATIONS

1. **Develop a comprehensive climate change policy to mitigate climate risk**

2. **Establish an independent Climate Resilience Advisory Committee – comprised of experts and relevant stakeholders – to inform the low-carbon transition process**

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[12] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory*.

[13] Pachauri et al., *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

[14] Rockström et al., "A Safe Operating Space for Humanity."; Steffen et al., "Trajectories of the Earth System in the Anthropocene."

[15] International Energy Agency, "Decoupling of Global Emissions and Economic Growth Confirmed"; Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5°C*.

[16] The Global Commission on the Economy and Climate, *Unlocking the Inclusive Growth Story of the 21st Century*.

[17] Ibid.

[18] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory*.

[19] Earth Systems and Climate Change Hub, *Climate Change Science for Northern Australia*.

[20] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5°C*.

[21] Gillis and Krauss, "Exxon Mobil Investigated for Possible Climate Change Lies by New York Attorney General Image"; Schwartz, "New York Sues Exxon Mobil, Saying It Deceived Shareholders on Climate Change."

EMISSIONS REDUCTION TARGET (NET ZERO BY 2050)

Without an emissions reductions target, the Northern Territory is forfeiting the opportunities associated with decarbonisation that other governments and organisations are seizing.

Falling behind the curve. Victoria has legislated a net zero emissions target by 2050 (with five yearly interim targets to meet the long-term target)[22]; NSW has committed to net zero by 2050[23]; Tasmania achieved net zero emissions in 2018[24]; South Australia has a net zero emissions by 2050 target and a legislated climate change framework[25]; Queensland has committed to net zero by 2050[26]; and the ACT recently revised their net zero emissions target from 2050 to 2045[27].

Over 9000 cities – representing over 780 million people - have joined the Global Covenant of Mayors for Climate Change & Energy; an international alliance of cities and local governments who are committed to transitioning to a low emission, resilient society[28].

Companies are also establishing science-based emissions reduction targets; enabling decarbonisation to be integrated into long-term decision-making and boosting competitive advantage. They include: McDonalds; NIKE; Nestle; Ericsson; Origin Energy; Westpac; and Teachers Mutual Bank[29]. Australia's red meat industry is investigating the potential to become carbon neutral by 2030, in collaboration with the CSIRO[30].

Investor confidence. The Corporate Leaders Group - bringing together business leaders to accelerate progress - has called for governments to adopt a net zero emissions target by 2050[31]. They argue this target will send a strong signal and galvanise business action; unlocking the innovation and creativity required to transition to a low-carbon economy. Members include: Unilever; Coca Cola; GlaxoSmithKline; and Lloyds Banking Group.

Enabling new insights and stimulating innovation. Mandating a target will also facilitate the integration of new – and advanced – approaches to inform long-term decision-making in the NT. For example, Google and the Global Covenant of Mayors have developed the Environmental Insights Explorer[32]; an online tool enabling cities instant access to emissions and climate projections data; as well as recommendations and resources to mitigate emissions and deliver substantial co-benefits.

RECOMMENDATION

1. **Legislate a science-based emissions reduction target of net zero by 2050. Include interim targets and sector-specific targets**

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[22] Victoria State Government, "Emissions Reduction Targets."
[23] Goverment of NSW, *Achieving Net-Zero Emissions by 2050*.
[24] Tasmanian Government, "Tasmania Achieves Zero Net Emissions for the First Time."
[25] Government of South Australia, "South Australian Climate Change Action."
[26] Department of Environment and Heritage Protection, *Pathways to a Clean Growth Economy: Queensland Climate Transition Strategy*.
[27] Burgess, "ACT Brings Forward Zero Net Emissions Deadline to 2045."
[28] Global Covenant of Mayors for Climate & Energy, "Global Covenant of Mayors for Climate & Energy."
[29] Science Based Targets, "Companies Taking Action."
[30] CSIRO, "The Australian Red Meat Sector Could Be Carbon Neutral by 2030."
[31] The Prince of Wales' Corporate Leaders Group, "Global Climate Action Summit: Governments Must Aim for Net Zero Carbon Emissions Before 2050, Say Business Leaders."
[32] Google and Global Covenant of Mayors for Climate & Energy, "Environmental Insights Explorer."

SECTION 3: MITIGATION OPPORTUNITIES FOR THE NT

There are significant opportunities inherent in decarbonising that need to be fully considered. Two of these are detailed here: maximising renewable energy generation and optimising energy efficiency in buildings.

These mitigative actions would meet the NTG's key priorities: increasing local jobs; growing research, innovation and training capacity; and contributing to energy security[33].

MAXIMISING RENEWABLE ENERGY GENERATION IN THE NORTHERN TERRITORY

Maximising renewable energy generation makes economic sense[34]. To achieve the Paris Agreement target, the power sector needs to be completely decarbonised by around 2050 (at the latest)[35].

This is now economically feasible, given the steep decline in the cost of renewable energy generation and storage and low-carbon technological advancements. The rapid decline in costs surpassed all expert projections in recent years and continued reductions are anticipated[36]. The International Renewable Energy Agency (IRENA) project that within two years all renewable energy generation technologies that are now in commercial use will either be cost comparable with fossil fuels or cheaper[37].

57 nations now have 100% renewable electricity targets[38] and in 2017, global investments in solar energy surpassed investments in gas, coal, and nuclear combined[39]. Investing in solar PV is now cheaper than developing new gas and coal power stations[40] and in many circumstances is even cheaper than running existing coal power stations[41].

The Australian Renewable Energy Agency (ARENA) report that in 2016-2017, there was a total of AUD1.2 billion in new renewable energy investment nation-wide[42]. Record levels of renewable energy generation are being consistently set in Australia[43]. Grid renewables and rooftop solar supplied 25.6% of total electricity supply in August, 2018[44]. 100% of Canberra's electricity will be delivered by renewable energy by 2020[45] and this transition delivers significant benefits; ACT's renewable energy program has *directly* contributed over $500 million in local economic benefits[46].

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[33] Gunner, "Creating Local Jobs - NT Gas Strategy Revealed."
[34] OECD/IEA, "World Energy Invest. 2018"; International Renewable Energy Agency (IRENA), *Energy and CO2 Emissions in the OECD*; IRENA, *Renewable Power Generation Costs in 2017*; Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.
[35] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5°C*.
[36] OECD/IEA, "World Energy Invest. 2018"; International Renewable Energy Agency (IRENA), *Energy and CO2 Emissions in the OECD*; IRENA, *Renewable Power Generation Costs in 2017*; Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.
[37] IRENA, *Renewable Power Generation Costs in 2017*.
[38] REN21, *Renewables 2018 Global Status Report*.
[39] United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.
[40] Bloomberg, *Bloomberg New Energy Outlook 2018*.
[41] Crooks, "New Wind and Solar Generation Costs Fall below Existing Coal Plants."
[42] Australian Renewable Energy Agency (ARENA), *ARENA Annual Report 16/17*.
[43] Saddler, *National Energy Emissions Audit*; ARENA, *The Business of Renewables*; Australian Renewable Energy Agency (ARENA), *ARENA Annual Report 16/17*.
[44] Saddler, *National Energy Emissions Audit*.
[45] ACT Government, "100% Renewable Energy for Canberra by 2020."
[46] ACT Government, *Canberra 100% Renewable*.

Businesses – large and small – have also realised the economic benefits of investing in renewable energy. Companies including Telstra, Sun Metals, and GFG Alliance are making significant investments in renewables[47]. Internationally, seven of the world's largest companies have made a commitment to 100% renewable energy generation, including: Microsoft; Apple; Google; IKEA; Johnson & Johnson; and Amazon[48].

According to extensive analysis *(Electricity Network Transformation Roadmap Report; 2017)* by the CSIRO and Energy Works Australia – the peak national body representing gas distribution and electricity transmission and distribution businesses– a transition to zero emissions electricity sector by 2050 is viable and can deliver a positive energy future for Australians: enabling choice; lower emissions; lower costs; and high security and reliability[49]. However, this pathway needs to be comprehensively planned for as soon as possible. Without an adequate transition strategy – including significant market reform and long term climate policy – the transition will be uncontrolled and highly inefficient[50].

Maximising renewable energy. Australia has the highest level of average solar radiation (per square metre) in the world; the annual solar radiation is approximately 10,000 times Australia's annual energy consumption. Solar energy resources are greatest in the northwest and centre of Australia[51].

In 2017, the NTG announced the Roadmap to Renewables target: an increase in renewable energy generation from 4% to 50% within the electricity sector by 2030[52].

This target aligns with a decarbonisation trajectory in the electricity sector, but it is crucial to consider: we only have 12 years until 2030, yet, energy infrastructure has a lifetime of approximately 40 years[53]. As such, infrastructural investments made now will have a life-time beyond 2050. To achieve decarbonisation in the electricity sector, a beyond-2030 target needs to be determined as soon as possible to ensure an optimal and cost-effective transition is achieved.

The target. A beyond-2030 target should aim to maximise renewable energy generation as much as is technologically feasible (up to 100%).

RECOMMENDATIONS - MAXIMISE RENEWABLE ENERGY GENERATION

1. **Set the post-2030 (maximising) renewable energy target, including interim targets, and begin the transition process**

2. **Determine the potential for different renewable energy technologies to contribute to the NT's future energy mix**

[47] The Climate Council, *Renewables & Business: Cutting Prices and Pollution*.
[48] ARENA, *The Business of Renewables*.
[49] CSIRO and Energy Networks Australia, *Electricity Network Transformation Roadmap: Final Report*.
[50] Parkinson, "Households Will Be at Centre of Australia's Transition to 100% Renewables"; CSIRO and Energy Networks Australia, *Electricity Network Transformation Roadmap: Final Report*.
[51] Australian Renewable Energy Agency (ARENA), *Australian Energy Resource Assessment (Chapter 10; Solar Energy)*.
[52] Langworthy et al., *Roadmap to Renewables: Fifty per Cent by 2030*.
[53] Union of Concerned Scientists, "Average Life Expectancy of Select Infrastructure Types and Potential Climate-Related Vulnerabilities."

There are significant co-benefits associated with decarbonisation of the power sector. These include (*but are not limited to*):

New job creation. Globally, there were 9.8 million jobs in the renewable energy sector in 2016 and this is projected to rise to 24 million by 2030[54]. In Australia, there are 13,900 jobs within the renewables sector, with 6,100 in solar photovoltaic[55].

Scenario modelling (Ernst & Young's Australian electricity forecast model) projects that if renewable energy generation growth increased from 34% of total electricity in 2030 (*business as usual* scenario), to 50% by 2030, over 28,000 new (additional) jobs would be created. These jobs would be created in: construction; operation; maintenance of renewable energy installations and related industries[56].

This needs to be compared to job growth rates under alternative energy pathways. As outlined by The Australia Institute (*Economies of Shale*; January, 2018), unconventional gas extraction in the NT is unlikely to provide significant economic benefit and has a high level of associated risk[57]. Independent economic analysis provided by ACIL Allen – commissioned by the Hydraulic Fracturing Scientific Inquiry – found there is a 'very high probability' that an unconventional gas industry would 'fail to commercialise' in the NT ('*Shale Calm*' scenario). In the highest production scenario ('*Shale Gale*' scenario) – deemed to have a 'very low' or 'low' level of probability of occurring – ACIL Allen estimate direct *and* indirect employment in the NT would translate to 524 full time equivalent jobs (compared to baseline case) [58]. This represents 0.5% of employment in the NT[59].

Attracting investment in the Territory. Chile's solar industry expanded so rapidly, electricity is being given for free[60]. While this can in part be attributed to inadequate infrastructural decision-making, it does provide an example of what is possible. If low-carbon electricity can be delivered at extremely low-cost – or under certain circumstances for free – to consumers, the Northern Territory could be in a strong position to attract new low-carbon industries and investment into the Territory[61].

Becoming a net energy exporter. South Australia (SA), previously a net energy importer – when it had only gas and local coal – are now a net exporter of electricity, in net annualised terms. This is attributed to SA harnessing the abundant renewable energy sources to generate electricity[62].

The Western Australian (WA) Government recently commissioned a renewable energy export feasibility study, finding it would be viable to export solar energy from northern Australia to Indonesia via a high voltage direct current (HVDC) cable, under the ocean. This project would capitalise on the significant – and continued - increase in renewable energy demand in ASEAN nations. The pilot project could potentially generate up to 2,000 permanent jobs in the Pilbara region in WA and more than 12,000 jobs across the state[63].

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[54] International Renewable Energy Agency (IRENA), "Job Creation."
[55] International Renewable Energy Agency (IRENA), "Renewable Energy Employment."
[56] The Climate Council, *Renewable Energy Jobs: Future Growth in Australia*.
[57] Campbell, *Economies of Shale: Submission on the Draft Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*.
[58] Consulting, *The Economic Impacts of a Potential Shale Gas Development in the Northern Territory*.
[59] Campbell, *Economies of Shale: Submission on the Draft Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*.
[60] Dezem and Quiroga, "Chile Is Producing so Much Solar Power It Has to Give It Away."
[61] Beyond Zero Emissions, *Electrifying Industry*; CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*; IRENA, *Hydrogen from Renewable Power: Technology Outlook for the Energy Transition*.
[62] Saddler, *National Energy Emissions Audit*.
[63] Fitzgerald, "Solar Energy Exports from the Pilbara to Indonesia the Focus of New WA Government-Backed Study"; Pilbara Development Commission and Government of Western Australia, *Pilbara Solar Export Pre-Feasibility Study*.

Economic viability. Even at today's costs, the Expert Panel for the Territory's Roadmap to Renewables Report determined that as a consequence of the rapid decline in the cost of producing renewable energy, the economic viability of renewable energy projects is largely guaranteed provided the appropriate financial mechanisms are in place[64].

Strong community support and engagement. A finding from the community consultations conducted during the development of the *Roadmap to Renewables Report* was a call from the community for the NTG to be more aggressive with regards to implementing renewables and for there to be greater support for businesses and households wanting to implement renewable energy technology[65].

Energy security in remote communities. Optimising renewable energy generation in remote communities – and phasing out diesel generation – would enable greater levels of energy security; lower risks to human health and the environment; and deliver substantial cost savings[66].

Decarbonising the transport sector. Maximising renewable energy generation is essential if the transport sector is to be decarbonised. A rapid and extensive deployment of electric vehicles - that are powered by clean electricity - is required if the transport sector is to decarbonise in line with the 1.5ºC target[67].

Establishing the NT as an international research hub. Alice Springs and Central Australia already have the initial infrastructure and research networks to become a world-leading solar research hub[68]. The NT's climatic diversity could be harnessed to understand how commercially viable renewable energy technologies respond to climatic variability. Results from solar energy research in the NT could be transferred to larger systems, both domestically and internationally. There is significant potential to establish the region as a leading research centre[69].

Development of new industries. In August, 2018, Australia's Chief Scientist chaired a Hydrogen Strategy Group briefing paper[70] for the Australian Federal Government. It was determined with production costs declining; technological advancements; and momentum building for decarbonisation, Australia is in a promising position to develop a hydrogen economy for national consumption and export. A blueprint for the development of a hydrogen industry in Australia is outlined in CSIRO's *National Hydrogen Roadmap*[71] (August, 2018). Domestically, it is estimated exports alone could contribute AU$1.7 billion and provide 2,800 jobs by 2030[72].

Renewable hydrogen. Renewable, or clean, hydrogen is an energy carrier – rather than a source- and is produced by splitting a water molecule into hydrogen and oxygen (electrolysis process utilising renewable energy). In comparison to fossil fuels - including natural gas - there are no carbon emissions released when it is burned; the only by-products are water vapour and heat[73] (*see:* Annex I for overview of hydrogen applications). Extensive energy is required for the electrolysis process,

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[64] Langworthy et al., *Roadmap to Renewables: Fifty per Cent by 2030*.
[65] Ibid.
[66] Green Energy Task Force, *Roadmap to Renewable and Low Emission Energy in Remote Communities*.
[67] Climate Action Tracker, "The Road Ahead : How Do We Move to Cleaner Car Fleets?"
[68] Langworthy et al., *Roadmap to Renewables: Fifty per Cent by 2030*.
[69] Ibid.; Northern Territory Government, *Northern Territory Climate Change Policy 2009*.
[70] *Hydrogen for Australia's Future: A Briefing Paper for the COAG Energy Council*.
[71] CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*.
[72] Hydrogen Strategy Group, *Hydrogen for Australia's Future: A Briefing Paper for the COAG Energy Council*.
[73] CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*.

however, with the rapid decline in the cost of solar energy, renewable hydrogen is becoming increasingly economically feasible[74].

The idea to utilise hydrogen as an energy source is not new, however strategic investments (private and public) across the hydrogen supply chain and technological developments – demonstrated across pilot projects globally – have led to a renewed focus on renewable hydrogen[75]. These technological advancements include a membrane technology – developed by the CSIRO - that will enable hydrogen to be safely transported and used as a mass production energy source[76]. The global hydrogen market is projected to reach over USD154 billion by 2022[77] and could potentially meet 18% of global final energy demand by 2050[78].

A local renewable hydrogen industry. The NT is in an optimal position to develop a renewable hydrogen industry for domestic and international consumption, with: high solar radiation; existing LNG infrastructure, which can be utilised to transport and store hydrogen; and geographical proximity to potential export markets[79].

International demand for hydrogen. Internationally, Japan, the world's third-largest economy (GDP), has developed a multi-decade plan to transition to a hydrogen-based society in a bid to decarbonise and achieve energy security[80]. Additionally, South Korea has signalled a strong commitment; Korea's hydrogen economy act will likely be passed in 2018[81]. Both nations are net energy importers (94% and 81% of total energy, respectively)[82]. Across Japan, South Korea, Singapore, and China, potential demand for imported hydrogen in is projected to reach AU$9.5 billion by 2030[83]. Currently, there are no large-scale exporters.

RECOMMENDATIONS

HARNESS NEW ECONOMIC OPPORTUNITIES (RENEWABLE ENERGY)

1. **Investigate potential pathways for the NT to become a net energy exporter**

2. **Determine the feasibility of attracting new industries to the NT with the incentive of inexpensive, clean, electricity**

3. **Explore the potential for the NT to become a world-leading research hub for renewable energy technology**

4. **Investigate the feasibility of establishing a renewable hydrogen industry in the NT**

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[74] IRENA, *Hydrogen from Renewable Power: Technology Outlook for the Energy Transition*; International Renewable Energy Agency (IRENA), *Technology Roadmap*.
[75] CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*; Hydrogen Strategy Group, *Hydrogen for Australia's Future: A Briefing Paper for the COAG Energy Council*; IRENA, *Hydrogen from Renewable Power: Technology Outlook for the Energy Transition*.
[76] CSIRO, "CSIRO Tech Accelerates Hydrogen Vehicle Future."
[77] MarketsandMarkets, "Hydrogen Generation Market Worth 154.74 Billion USD by 2022."
[78] Hydrogen Council, *Hydrogen Scaling up: A Sustainable Pathway for the Global Energy Transition*.
[79] Hydrogen Strategy Group, *Hydrogen for Australia's Future: A Briefing Paper for the COAG Energy Council*; CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*.
[80] Agency for Natural Resources and Energy, *Basic Hydrogen Strategy Determined*.
[81] Ji-hye, "[Hydrogen Korea] 'Hydrogen Economy Act Will Be Passed This Year.'"
[82] Kan and Shibata, *Evaluation of the Economics of Renewable Hydrogen Supply in the APEC Region*; Hydrogen Strategy Group, *Hydrogen for Australia's Future: A Briefing Paper for the COAG Energy Council*.
[83] CSIRO, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia*; ACIL Allen Consulting for ARENA, *Opportunities for Australia from Hydrogen Exports*.

NATURAL GAS: *NOT* A BRIDGING FUEL FOR THE TRANSITION TO RENEWABLES

In the *Climate Change Discussion Paper*, natural gas is advanced as an important energy source in the transition to a low-carbon future. This assumption is *not* supported by evidence.

The ***GHG emissions of natural gas from hydraulic fracturing is greater than that of other fossil fuels*** on time scales of up to 100 years. The GHG emissions of natural gas from hydraulic fracturing is *at least* 20% greater than that of coal over a 20-year time scale. Over a 100-year time scale, it is comparable to coal[84].

Fugitive methane emissions. Unconventional natural gas extraction – hydraulic fracturing – is irreconcilable with mitigating climate risk and limiting global warming to $1.5\,^{o}C$ [85]. During the hydraulic fracturing process, methane emissions are released (*fugitive emissions*; unintended emissions released during extraction). Methane captures 28 times more heat in the atmosphere than carbon dioxide over a 100-year time-frame[86].

The feasibility of offsetting emissions. The Scientific Inquiry into Hydraulic Fracturing in the NT found that even *after* the mitigation of fugitive emissions, the life-cycle greenhouse gas emissions risk level was *unacceptable*[87]. In response, the Inquiry recommended all emission be offset. Recent analysis by The Australia Institute suggests the (annual) offsetting cost could reach AUD4.3 billion in 2030 and the cumulative cost of offsets from 2030-2040 (likely operational life of gas fields) could reach AUD146 billion[88].

Renewable energy is (already) cheaper than fossil fuels[89]. AGL Energy – Australia's largest integrated energy company – projects Australia's transition away from coal will bypass gas and shift straight to solar[90].

Economic considerations. When available, the operating costs of solar generators are close to zero[91]. The pay-back time for battery storage can be rapid, as demonstrated with the example of Tesla's lithium-ion battery in South Australia, which is on track to make back a third of its total construction cost (AUD 90.6 million) in its first year of operation[92]. Combined cycle gas with open cycle gas turbine generators – run to provide grid resilience – are the most expensive form of electricity generation, behind brown coal generators and black coal generators[93].

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[84] Howarth, Santoro, and Ingraffea, "Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations"; Howarth, Santoro, and Ingraffea, "Venting and Leaking of Methane from Shale Gas Development: Response to Cathles et Al."
[85] Tyndall Centre for Climate Change Research Manchester et al., *Natural Gas and Climate Change*; The Australia Institute, "Open Letter to The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory and the Northern Territory Government."
[86] Myhre et al., "Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change."
[87] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, *Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*.
[88] Ogge, *Options for the Implementation of Recommendation 9.8 of NT Fracking Inquiry*.
[89] Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.
[90] Vorrath, "AGL Kills Idea of Gas as Transition Fuel: Wind, Solar + Storage Cheaper."
[91] Saddler, *National Energy Emissions Audit*.
[92] Wahlquist, "South Australia's Tesla Battery on Track to Make Back a Third of Cost in a Year."
[93] Saddler, *National Energy Emissions Audit*.

The *Discussion Paper* states natural gas exports will play an important role displacing coal – an energy source with higher embodied carbon – to gas. However, with the continued sharp decline in renewable energy costs, economies are bypassing gas and transitioning straight to renewables[94].

For example, in India; a country advanced as a potential export market for the Territory's natural gas reserves[95], renewable energy is already displacing coal[96]. Approximately 25% of India's coal-fired pre-construction projects were cancelled from February to August 2018 (24 GW; an amount equal to 55% of Australia's existing *total* operating capacity)[97]. In June 2018, Bloomberg New Energy Finance estimated the cost of solar and wind in India is now 50% cheaper than coal[98]. The same month, the Indian Government announced an intent to launch a tender for 100 gigawatts of solar power – ten times the size of the world's largest current solar tender[99].

In the United States, the transition away from natural gas is already observable. Regulators in Arizona – a politically conservative state with no renewable energy mandate – rejected the integrated resource plans of Arizona's major utilities, citing too much reliance on natural gas and the risk of stranded assets[100]. The utilities are now soliciting battery storage, for what will become one of the largest projects in the U.S.[101] In January 2018, Californian regulators rejected a bid from Pacific Gas & Electric to continue payments to three natural gas plants. Instead, they were required to solicit bids for energy storage[102]. In the United States, gas consumption declined in 2017, for the first time in seven years. This was attributed to lower electricity demand and competition from renewable energy[103].

Mitigating climate risk. The role of gas looks to be further displaced in Australia, as Governments take climate risk into consideration. In Canberra, Ginninderry – a new 11,500-home suburb set for development in 2020 - will become the first gas-free suburb. It will be completely powered by renewable energy. The ACT's Climate Change Minister, Shane Rattenbury, stated, 'Gas is going to be a significant source of emissions we're going to need to tackle here in the ACT'[104].

RECOMMENDATIONS

1. **Natural gas should *not* be advanced as a low-carbon bridging fuel for the transition to renewables**

2. **Economic modelling; decarbonisation; and climate risk must be integrated into the decision-making process when determining the NT's development pathway**

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[94] Climate Action Tracker, *Foot off the Gas: Increased Reliance on Natural Gas in the Power Sector Risks an Emissions Lock-in: Analysis*; IRENA, *Renewable Power Generation Costs in 2017*; International Renewable Energy Agency (IRENA), *Energy and CO2 Emissions in the OECD*; Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.

[95] Reuters, "Australia's Darwin Seeks to Shed Frontier Image to Become World-Class LNG Export Hub."

[96] Anand, "India, Once a Coal Goliath, Is Fast Turning Green"; Johnston, "India Cancels Plans for Huge Coal Power Stations as Solar Energy Prices Hit Record Low"; Buckley, *IEEFA Asia: India's Electricity-Sector Transformation Is Happening Now*; Michael Safi, "India's Huge Solar Ambitions Could Push Coal Further into Shade."

[97] Buckley and Shah, "India Coal Project Cancellations Snowballing"; Buckley, *IEEFA Asia: India's Electricity-Sector Transformation Is Happening Now*.

[98] Bloomberg, *Bloomberg New Energy Outlook 2018*.

[99] Michael Safi, "India's Huge Solar Ambitions Could Push Coal Further into Shade."

[100] Roberts, "Clean Energy Is Catching up to Natural Gas."

[101] Maloney, "Taming the Duck: Arizona Public Service Seeks 106 MW Storage for Solar Plants."

[102] Roselund, "California Regulators Choose Clean Energy and Storage over Existing Gas Plants."

[103] Enerdata, "Natural Gas."

[104] Burgess, "Ginninderry to Be First Canberra Suburb without Natural Gas."

ENERGY EFFECIENCY IN BUILDINGS

Energy efficiency is the process of reducing energy demand without compromising end-use services. Buildings – and activity within them – account for approximately 31% of global final energy demand[105]. Indirect emissions in the building sector – emissions from heat and electricity – will need to rapidly decline by 65-70% by 2030 and be completely phased out by 2050 to stay well below 2°C[106]. Energy efficiency is one of the most cost-effective mitigation strategies to pursue.

The approaches detailed below can be undertaken with today's technologies. In addition to stimulating economic growth, energy efficiency leads to improved health outcomes for building occupants (monetised value equal to approximately 8-22% of the realised cost saving)[107]. Three approaches are detailed below. Additional approaches will need to be considered, for example, evidence-based demand management strategies.

Retrofitting. An energy retrofit entails modifying existing buildings to reduce energy demand. Retrofits range from *minor retrofits* (e.g. upgrading lighting systems and appliances; together, they represent 55% of total emissions in the building sector)[108] to *deep retrofits*, where extensive measures are implemented in unison. Average retrofit payback time is five to seven years[109]. Financing mechanisms need to be operationalised to enable wide-scale energy retrofits[110].

New builds and building standards. Building codes optimising energy efficiency in new developments must be mandated[111]. Codes can be adapted from other jurisdictions. For example, in 2018, California mandated all new residential construction will achieve net zero emissions by 2020. This will be achieved by ensuring energy efficiency potential is maximised and any remaining energy demand is offset with rooftop solar PV. Benefits include negligible energy costs for residents[112].

Climate resilient design. The NT could establish itself as a climate resilient design leader (e.g. passive cooling designs that provide thermal comfort with limited (or no) energy consumption)[113].

RECOMMENDATIONS

1. **Undertake energy retrofits across the Territory's building stock to optimise energy savings. Investigate complementary strategies to increase energy efficiency (e.g. demand management).**

2. **Mandate energy efficiency building codes to maximise emission reductions and cost savings. Ensure these are consistently updated to reflect technological advancements**

3. **Establish the NT as a hub for climate resilient and sustainable design**

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[105] International Energy Agency (IEA), *Meeting Climate Change Goals through Energy Efficiency*.
[106] Climate Action Tracker, "Constructing the Future: Will the Building Sector Use Its Decarbonisation Tools? CAT Decarbonisation Series."
[107] The Global Commission on the Economy and Climate, *Unlocking the Inclusive Growth Story of the 21st Century*; Levy, Nishioka, and Spengler, "The Public Health Benefits of Insulation Retrofits in Existing Housing in the United States."
[108] Climate Action Tracker, "A Policy Spotlight on Energy Efficiency in Appliances & Lights Could See Big Climate Gains."
[109] Hawken, *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*.
[110] Climate Action Tracker, "A Policy Spotlight on Energy Efficiency in Appliances & Lights Could See Big Climate Gains"; Hawken, *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*.
[111] Climate Action Tracker, "A Policy Spotlight on Energy Efficiency in Appliances & Lights Could See Big Climate Gains."
[112] Delforge, "CA 2020 Building Code Draft: Zero-Net-Electricity New Homes."
[113] Santamouris and Kolokotsa, "Passive Cooling Dissipation Techniques for Buildings and Other Structures: The State of the Art."

SECTION 4: RISKS NOT TAKEN INTO CONSIDERATION

There are risks that are not accounted for in the *Discussion Paper.* Two are detailed here: 1) Economic risk of stranded fossil fuel assets; 2) Risk of litigative action

STRANDED ASSETS

As economies transition to a low-carbon growth trajectory, there is a risk of fossil fuel assets being stranded[114]. This is not accounted for in the *Climate Change Discussion Paper*, yet this poses significant risks to the Territory's economic growth.

Low-carbon technological advancements; energy efficiency; and decarbonisation strategies are reducing the demand for fossil fuels[115]. This increases the risk of fossil fuel assets becoming *stranded* by an unanticipated write-down; devaluation; or conversion to a liability[116].

A 2018 study published in *Nature Climate Change* – a leading scientific journal - found even without strict mandated emissions reductions targets *or* any additional climate change policies, the magnitude of loss from stranded fossil fuel assets could amount to a discounted global wealth loss of USD1-4 trillion. There would be distributional effects; emissions-intensive resource-based economies will be most impacted, for example, Russia; the United States; and Canada could see their fossil fuel industries nearly shut down[117].

To put this global wealth loss of USD1-4 trillion in perspective, the subprime mortgage market value loss realised after the 2008 financial crisis was approximately USD0.25 trillion. This market value loss led to a global stock market capitalisation decline of approximately USD25 trillion[118].

The economics of renewable energy generation - and the consistently declining prices – means that (already) renewables are cheaper than fossil fuels[119].

The next 2-3 years is a critical window: when investment and policy decisions will be made that will shape the upcoming decades[120], especially given the lifetime of energy infrastructure (up to 40 years)[121].

RECOMMENDATION

1. **The NTG needs to factor the global low-carbon transition - and the subsequent risk of stranded fossil fuel assets - into government decision-making processes**

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[114] International Renewable Energy Agency (IRENA), *Stranded Assets and Renewables*; Climate Action Tracker, *Foot off the Gas: Increased Reliance on Natural Gas in the Power Sector Risks an Emissions Lock-in: Analysis*; Mercure et al., "Macroeconomic Impact of Stranded Fossil Fuel Assets."

[115] Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*; International Renewable Energy Agency (IRENA), *Energy and CO2 Emissions in the OECD*; International Renewable Energy Agency (IRENA), *Stranded Assets and Renewables*.

[116] International Renewable Energy Agency (IRENA), *Stranded Assets and Renewables*.

[117] Mercure et al., "Macroeconomic Impact of Stranded Fossil Fuel Assets."

[118] Ibid.

[119] Bloomberg, *Bloomberg New Energy Outlook 2018*; United Nations Environment Programme and Bloomberg New Energy, *Global Trends in Renewable Energy Investment 2018*.

[120] Global Commission on the Economy and Climate, "Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action In Urgent Times"; Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5°C*.

[121] Union of Concerned Scientists, "Average Life Expectancy of Select Infrastructure Types and Potential Climate-Related Vulnerabilities."

DUTY OF CARE AND HUMAN RIGHTS (RISK OF LITIGATIVE ACTION)

NT's emission profile. According to the *Climate Change Discussion Paper*, natural gas extraction may cause the NT's carbon emissions to more than double in the next 8 years. These projections *do not* include an increase in GHG emissions associated with industry growth in offshore gas[122].

These emissions are *significant*. Analysis by The Australia Institute found if all shale gas in the NT was exploited, resulting emissions could be equivalent to sixty times Australia's current annual emissions or building 130 coal power plants and operating these plants for forty years[123].

Insufficient action given the threat. If the NTG does not transition to a low-carbon pathway, this may expose to the NTG to a risk of litigative action. There is legal precedent for this. On 9 October, 2018, the Dutch appeals court upheld a legal order on the Dutch Government to accelerate emissions cuts. The case was brought on behalf of 886 Dutch citizens[124]. The Court ruled that the severity and the scope of the climate crisis demanded GHG emissions reductions of at least 25% by 2020 (from a 1990 baseline). This is higher than the Dutch Government's 17% reduction target (by 2020)[125]; deemed to be *insufficient* to limit global warming to below 2 ºC[126].

Serious risk. The judges ruled the current emissions reduction target was unlawful, given the scale of the threat posed by climate change. The Court stated (*October, 2018*): 'It is appropriate to speak of a real threat of dangerous climate change, resulting in the serious risk that the current generation of citizens will be confronted with loss of life and/or a disruption of family life … [T]he State has a duty to protect against this real threat'(Para. 45)[127]. The case was brought under human rights and tort law[128].

In addressing the Dutch contribution to global climate emission of 0.5%, the Court stated (*June, 2015*): '[I]t has been established that any anthropogenic greenhouse gas emission, no matter how minor, contributes to an increase in carbon dioxide levels in the atmosphere and are therefore hazardous to climate change' (Para. 4.79)[129]. The Court found a sufficient causal link could be established between Dutch emissions, global climate change, and the impacts[130].

The Court noted that as a developed country, the Netherlands was in a position to reduce emissions and that adaptation measures *could not* compensate for the Government's duty of care to mitigate GHG emissions[131].

RECOMMENDATION

1. **Take legal duty of care (tort law) and human rights into consideration when developing the NTG's response to climate change**

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[122] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory*.
[123] Ogge and Campbell, *Submission on the Draft Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory: Greenhouse Gas Emissions*.
[124] Urgenda, "The Urgenda Climate Case against the Dutch Government."
[125] Nelsen, "Dutch Appeals Court Upholds Landmark Climate Change Ruling."
[126] Grantham Research Institute on Climate Change and the Environment, "Urgenda Foundation v. Kingdom of the Netherlands (District Court of the Hague, 2015)"; Uitspraken, "Uitspraken (ECLI:NL:GHDHA:2018:2610)."
[127] ELAW, "Urgenda Foundation v. The State of the Netherlands"; Uitspraken, "Uitspraken (ECLI:NL:GHDHA:2018:2610)."
[128] Nelsen, "Dutch Government Ordered to Cut Carbon Emissions in Landmark Ruling."
[129] ELAW, "Urgenda Foundation v. The State of the Netherlands."
[130] Ibid.
[131] Nelsen, "Dutch Government Ordered to Cut Carbon Emissions in Landmark Ruling"; Uitspraken, "Uitspraken (ECLI:NL:GHDHA:2018:2610)"; ELAW, "Urgenda Foundation v. The State of the Netherlands."

SECTION 5: ADAPTATION

CLIMATE RISK ASSESSMENT AND ADAPTATION STRATEGY

No comprehensive climate risk assessment has been undertaken for the NT. It is not possible to mitigate climate risk and adapt when the extent of the risks are not established.

Risks from climate change arise from the interaction between a *hazard* (triggered by an event or trend related to climate change), *vulnerability* (susceptibility to harm) and *exposure* (people, assets or ecosystems at risk)[132].

The extent of the risks for the NT are not established. A climate risk assessment is required as a matter of urgency.

In addition to the requirement for a comprehensive risk assessment, the following should be considered:

Impacts. The projected impacts for the Territory will be *severe*. This is not extensively considered in the *Discussion Paper*. For example, the *Paper* states (global average) temperature is projected to increase by 2.7 ºC – 4.9 ºC by 2100[133]. However, this range far exceeds the Paris Agreement Target and what is considered 'safe' for most nations; communities; ecosystems; and sectors and poses significant risks to natural and human systems (when compared to current global warming of 1ºC)[134].

It is critical to note, even within the Paris Agreement range, climate risks are high. For example:

- Coral reefs would decline by 70-90 percent with global warming of 1.5°C, whereas virtually all (> 99 percent) would be lost with 2ºC. at 1.5°C[135]; and
- The frequency of warm extreme temperatures over land will increase by 149% over Northern Australia at 1.5°C, at 2ºC, this increases to 406%[136]

Short-term and mid-term projections are required. The *Discussion Paper* outlines projected impacts in 2100[137], yet impacts are already observable. For example, a 2018 report from independent research think tank, The Australia Institute, found that the number of days over 35 ºC per year in Darwin had increased from 5.6 days per year in the early 20th century to over 20 days per year in the last five years (days over 35 ºC and with > 70% humidity are considered *extremely dangerous*)[138].

CSIRO climate models predict that without drastic reductions in GHG emissions, the number of days over 35 ºC would increase to 132 over the next 12 years[139]. This would have severe implications on health; productivity; agriculture; construction; and tourism. Ecosystems would be severely affected and the standard of living would greatly decline.[140] These observed or projected impacts have not been considered to the extent that is warranted in the *Discussion Paper.*

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[132] Pachauri et al., *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*
[133] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory.*
[134] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC.*
[135] Ibid.
[136] Carbon Brief, "The Impacts of Climate Change at 1.5C, 2C and Beyond."
[137] Northern Territory Government, *Climate Change: Mitigation and Adaptation Opportunities in the Northern Territory.*
[138] Hanna and Ogge, *Cooked with Gas: Extreme Heat in Darwin.*
[139] Ibid.
[140] Ibid.

Severity of the impacts. Projected impacts in the NT include (*but are not limited to*):

- Increase in the number of ***extreme heat days***. CSIRO modelling estimates the average number of extreme heat days (days over 35°C; > 70% relative humidity) – classified as *extremely dangerous* - could increase from 22.2 per year to 132 per year in 12 years (2030)[141]*;*
- ***Human health***: Increased risk of exposure to extreme weather events projected to increase: ***heat-related mortality and morbidity***; greater frequency of ***infectious disease epidemics***[142]. Increased intensity of ***extreme rainfall events***[143] projected to increase risk of Murry Valley encephalitis; Ross River virus; melioidosis; and infectious enteric diseases[144];
- Higher temperatures (and increase in threats, e.g. pests and spread of disease) projected to adversely affect ***primary industries*** (e.g. lower yields; risks to livestock; risks to fisheries)[145];
- Increase in the intensity (and related damage) of ***tropical cyclones***[146] and more ***extreme fire behaviour***[147]. Intensity and frequency of ***droughts*** projected to increase[148];
- Increase in ***mean sea level rise***; increased risk of ***extreme sea-level events****;* and ***erosion***[149]*;*
- ***Natural ecosystems*** placed at high risk (e.g. extensive mangrove dieback)[150]; ***species loss and extinction (the sixth mass extinction is already under way)***[151];
- High risk of ***saltwater intrusion in Kakadu***. Temperature increase of 2-3°C projected to lead to the loss of 80% of freshwater wetlands in Kakadu[152]

It must be noted, *certain sectors of society will be disproportionately affected*. The worst impacts are expected amongst those with the least capacity to adapt; indigenous people; those working outdoors; children and the elderly; and those with agricultural or coastal dependent livelihoods[153]

RECOMMENDATIONS

1. **As a matter of urgency, climate change risks for the Northern Territory need to be comprehensively investigated and determined (climate risk assessment)**

2. **An adaptation strategy then needs to be developed, taking into account both short- and long-term climate risks and differentiated impacts**

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[141] Ibid.
[142] Nikolakis, Nygaard, and Grafton, *Adapting to Climate Change for Water Resource Management: Issues for Northern Australia*; Green, *Climate Change and Health: Impacts on Remote Indigenous Communities in Northern Australia*; World Health Organisation, "Climate Change and Human Health - Risks and Responses. Summary."
[143] Climate Change in Australia et al., "Climate Change in Australia."
[144] Whelan et al., "Rainfall and Vector Mosquito Numbers as Risk Indicators for Mosquito-Borne Disease in Central Australia"; Green, *Climate Change and Health: Impacts on Remote Indigenous Communities in Northern Australia*.
[145] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*; Climate Change in Australia et al., "Climate Change in Australia"; Cobon et al., "The Climate Change Risk Management Matrix for the Grazing Industry of Northern Australia"; Nikolakis, Nygaard, and Grafton, *Adapting to Climate Change for Water Resource Management: Issues for Northern Australia*.
[146] Earth Systems and Climate Change Hub, *Climate Change Science for Northern Australia*; Climate Change in Australia et al., "Climate Change in Australia."
[147] Climate Change in Australia et al., "Climate Change in Australia."
[148] Green, *Climate Change and Health: Impacts on Remote Indigenous Communities in Northern Australia*; Nikolakis, Nygaard, and Grafton, *Adapting to Climate Change for Water Resource Management: Issues for Northern Australia*.
[149] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*; Hennessy et al., *Climate Change in the Northern Territory*; Nikolakis, Nygaard, and Grafton, *Adapting to Climate Change for Water Resource Management: Issues for Northern Australia*.
[150] Duke et al., "Large-Scale Dieback of Mangroves in Australia's Gulf of Carpentaria: A Severe Ecosystem Response, Coincidental with an Unusually Extreme Weather Event"; Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*.
[151] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*; Barnosky et al., "Has the Earth's Sixth Mass Extinction Already Arrived?"; Ceballos et al., "Accelerated Modern Human–Induced Species Losses: Entering the Sixth Mass Extinction."
[152] Bayliss et al., "An Integrated Risk-Assessment Framework for Multiple Threats to Floodplain Values in the Kakadu Region, Australia, under a Changing Climate"; BMT WBM, *Kakadu-Vulnerability to Climate Change Impacts. A Report to the Australian Government Department of Climate Change and Energy Efficiency*; Nikolakis, Nygaard, and Grafton, *Adapting to Climate Change for Water Resource Management: Issues for Northern Australia*.
[153] Intergovernmental Panel on Climate Change (IPCC), *IPCC Special Report on Global Warming of 1.5ºC*.

SECTION 6: CROSS-SECTORAL ENGAGEMENT

Climate change considerations need to be integrated into all decision-making – across the board. The risks are *severe*, and need to be addressed appropriately. Effectively mitigating climate risk will enable unprecedented transitions across the Territory. The *IPCC Special Report* outlined the vital importance of effectively engaging *all* community members in this transition process[154].

Engaging all Territorians. To effectively engage Territorians, the NTG must clearly communicate the risks inherent in climate change and the avenues to mitigate emissions and adapt. In addition, the NTG must ensure Territorians have the skills and resources required to enhance climate resilience.

Communicating climate change. There are extensive resources available to inform governments and organisations on the best avenues to communicate climate change. They include *A guide to the science of climate change communication;* developed by the Tyndall Centre for Climate Change Research and Climate Outreach. Topics include: knowing your audience; communicating uncertainty; and bringing climate change into the here and now[155].

E**nabling capacity.** The NTG and local governments must develop innovative mechanisms to encourage engagement across the Territory. Examples of successful approaches – implemented both domestically and internationally - can be adapted to the Northern Territory context.

The Sustainable Melbourne Fund (SMF) offers an avenue to overcome a key barrier to increasing climate resilience: financing. The SMF was established by the City of Melbourne Council – in collaboration with councils - to provide low cost and accessible finance to engage sustainability projects, such as providing upfront capital to fund investments in renewable energy. The fund administers loans through Environmental Upgrade Agreements and these are repaid quarterly through council rates. As of August, 2017, the SMF had saved small and medium businesses $1.5 million every year and reduced GHG emissions by over 5000 tonnes[156].

The NTG's 2009 Climate Change Policy also highlights examples of avenues to increase capacity and community climate resilience. For example, providing funding directly to Territory community groups to develop and implement climate solutions[157].

Connecting to the climate change networks. Both nationally and internationally, Governments are transitioning to a low-carbon economy. There are networks the NTG can join to ensure the NT's transition is informed by evidence and best-practice. These include the *Adaptation Research Network*, facilitated by the National Climate Adaptation Research Facility, within which scientists and practitioners work together to advance climate change adaptation[158].

RECOMMENDATION

1. **Implement evidence-based mechanisms to engage all Territorians in building climate resilience**

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[154] Ibid.
[155] Tyndall Centre for Climate Change Research & Climate Oureach, "A Guide to the Science of Climate Change Communication."
[156] Sustainable Melbourne Fund, "Sustainable Melbourne Fund"; The Climate Council, *Renewables & Business: Cutting Prices and Pollution*.
[157] Northern Territory Government, *Northern Territory Climate Change Policy 2009*.
[158] National Climate Adaptation Research Facility, "Adaptation Networks."

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———. *Canberra 100% Renewable*. Canbeera, 2016.

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ARENA. *The Business of Renewables*. Canberra, 2017.

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ANNEX I

Energy of the future: Renewable hydrogen

What could renewable hydrogen be used for?

- *Grid resilience:* Promisingly, hydrogen could play an integral role in developing resilience in the energy grid; it provides a fast responding load for variable renewable energy generation, thereby addressing energy intermittency challenges associated with renewable energy generation[159].
- *Domestic cooking and heating/manufacturing:* With modifications to the existing gas networks and appliances, hydrogen can replace natural gas for domestic cooking and heating[160].
- *Energy security in remote areas:* With the cost of energy from hydrogen and fuel cells projected to become commercially competitive with diesel equivalents before 2025[161], there is potential to displace diesel as a primary fuel source in remote locations.

Renewable hydrogen could also play a role in reducing carbon emissions in sectors that have been traditionally difficult to decarbonise[162], including:

- *Manufacturing:* Renewable hydrogen can replace fossil fuels in carbon intensive manufacturing processes including steel, fertiliser, and cement[163].
- *Transport:* Hydrogen fuel cells are an alternative to batteries for electric motors. The Japanese Government aims to have 40,000 hydrogen fuel cell cars on the road by 2020[164] and there is anticipated future domestic demand for hydrogen-powered long-haul transport (buses; trucks; trains; ships)[165]. In 2020, the first hydrogen road train is being released in the US; it can travel up to 1900 km on a single hydrogen fuel cell[166].

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