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Climate change vulnerability assessment for the uranium supply chain in Australia

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ABSTRACT

Uranium demand is expected to increase due to the worldwide growth in electricity demand and the shift towards more sustainable and reliable low carbon energy sources. For more than 10 years, the Australian uranium industry production (primarily represented by production from the Ranger and Olympic Dam Mines) has been affected by adverse weather conditions. Since Australia meets 12% of the current world uranium demand, there is a need to study, at depth, any potential threat to this market. This study has included a vulnerability assessment of the impact that climate change currently makes, and potentially might have on the supply chain of the two biggest uranium mines currently operating in Australia. The assessment identified the most vulnerable parts (past and future) of both operational chains, in addition to the chain participants with the greatest and least adaptive capacity.

1. Introduction

The energy sector has been classified as the greatest worldwide contributor of Greenhouse Gas Emissions (GHGs). In 2010 it contributed 35% of total GHGs (Bruckner et al., 2014). Within the energy sector, electricity is the end-use of energy consumption with the greatest utilization occurring in the most recent years (Bruckner et al., 2014). Together with renewable sources of energy, uranium has been argued as an alternative cleaner source of energy (IPCC, 2014). While it produces a range of hazardous contaminants that require rigorous procedures for containment, it is nevertheless a lesser GHG pollutant compared with other sources (e.g. coal). For example, lifecycle emissions of nuclear power are 29 tonnes CO_2e/GWh compared to 888 tonnes CO_2e/GWh for coal (WNA, 2011). In light of this, worldwide demand for uranium is expected to increase in the future, from 82,000 tonnes in 2017 to 89,600 tonnes in 2019 (NEA and IAEA, 2016; AG, 2017). While Australian exports are expected to decrease by 1.3% during FY 2017–2018 (due to a temporary halt in production at Olympic Dam mine), by FY 2018–2019 an increase of 1.6% is projected (AG, 2017).

Australia has 34% of worldwide uranium resources recoverable at a cost of less than US$130 per kilogram, which is about 1,287,000 tonnes (ASNO, 2017). At the present time (2018) there are three operating uranium mines Ranger Mine (owned by Energy Resources of Australia – ERA), Olympic Dam (owned by BHP Billiton) and the Four Mile Mine (Beverley Mine) (WNA, 2017). Together, the Ranger Mine and Olympic Dam Mine represent more than 80% of the domestic Australian uranium oxide output in the years 2013–2016, and supply 12% of the global demand (WNA, 2017). Their locations are presented in Fig. 1.

The operational profitability of the two main uranium mines (Ranger Mine and Olympic Dam) in Australia have previously been affected by spot price, production costs and market fluctuations as well as by climate conditions and extreme weather events (more details at Pizarro et al., 2017). For example, extreme weather events such as heavy storms, heavy flooding, and cyclones have had significant operational and economic repercussions for Ranger Mine. A review of the company operation reports over 10 years (2006–2016) allowed the identification climate impacts, which are summarised below.

- Mining and the processing plant were halted frequently (ERA, 2007a; ERA, 2008a; ERA, 2011; ERA, 2012).
- Operational pit was flooded several times, this prevented access (total or partially) to the high-grade ore (ERA, 2007a; ERA, 2008a; ERA, 2009; ERA, 2010; ERA, 2011; ERA, 2012).
- Tailing storage facilities and/or Pond Water were also flooded (ERA, 2007a; ERA, 2010; ERA, 2011; ERA, 2012).
- The main road access to the mine (Arnhem highway) was closed for most March 2007 (ERA, 2008a).

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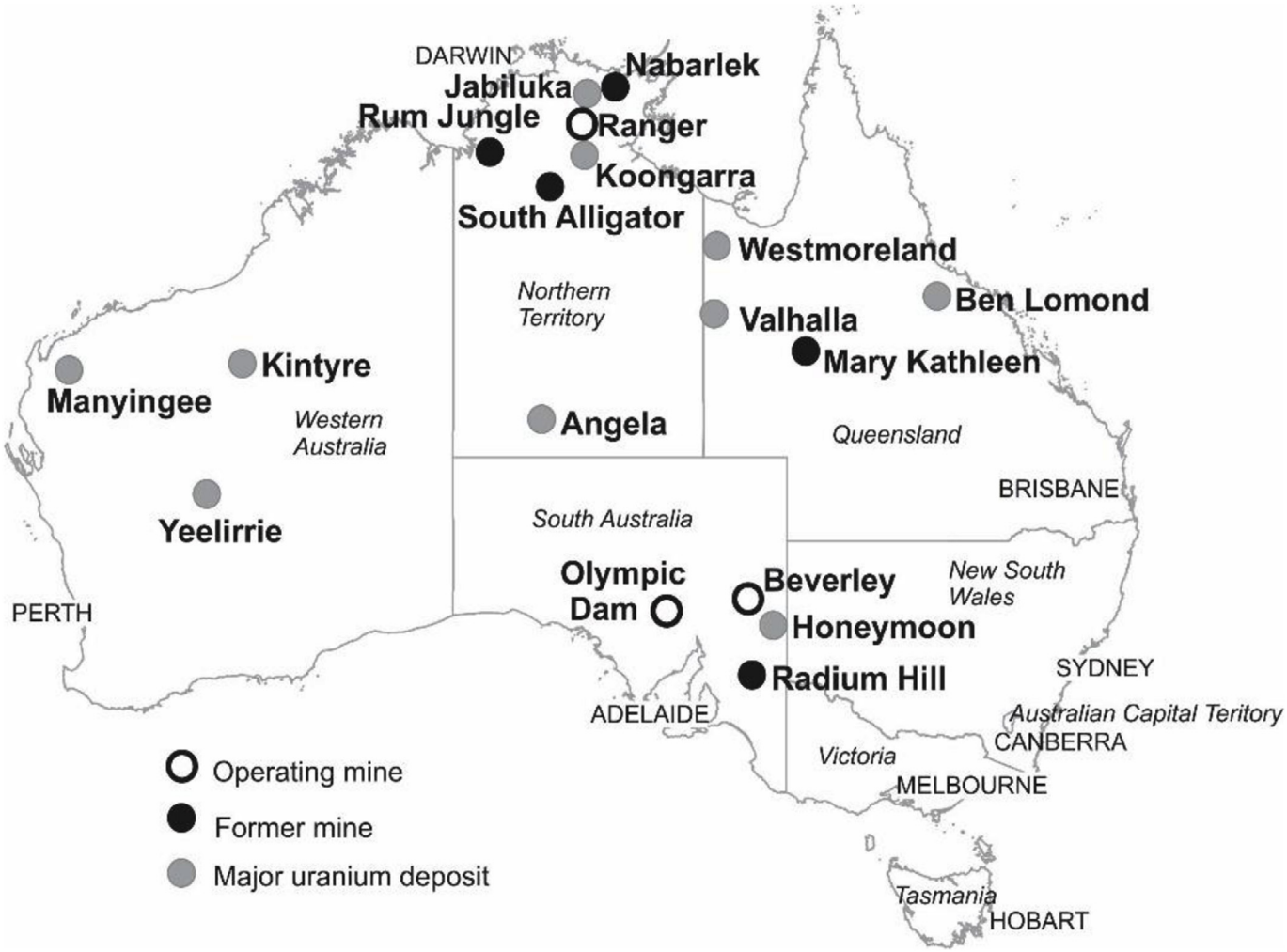

Fig. 1. Location of Ranger mine and Olympic Dam in addition to uranium deposits and former uranium mines (Source: after Australian uranium, 2017).

- Interruptions in power and water services in 2015.

The impacts on the Ranger Mine were associated with loss of production, which led to the need to purchase the mineral elsewhere (at higher costs and increased capital expenditure) in the market to fulfil contract obligations. All in all, this represented an estimated economic loss of A$934.5 million in the 2006–2016 period. It was clear that climate conditions and the extreme weather events also affect the supply chain and the external group of stakeholders. To study in depth how they have been affected and how they likely will be affected in the future, a vulnerability assessment (based on the concept of vulnerability employed by IPCC, 2001–2007, summarised by Jurgilevich et al., 2017) has previously been performed. The vulnerability assessment characterises the parameters of vulnerability (exposure, sensitivity and adaptive capacity) at each of the mines. This has been completed through a study of supply chain participant responses for each of the mines. This assessment has used the "lessons learned" from past extreme weather events to estimate future vulnerability.

2. Summary of climate projections in mine locations

A simplified review of the historical climate conditions at each the Ranger and Olympic Dam Mines along with climate projections are presented below. Four Representative Concentration Pathways (RCPs) have been considered in this research that include RCP2.6 (Van Veurren et al., 2011; Jubb et al., 2016), RCP4.5 (Van Veurren et al., 2011), RCP6 (Hijioaka et al., 2008), and RCP8.5 (Riahi et al.,2007).

Due to the uncertainties in the climate projections, the IPCC (2007) developed confidence criteria to qualify the level of certainty of each of the projections. Qualifiers such as '*very high*', '*high*', '*medium*', '*low*' and '*very low*' for each of the RCPs have been defined. The same confidence criteria have been used herein.

2.1. Ranger mine location and climate

The Ranger Mine is located 251.5 km east of Darwin in the Northern Territory. The closest meteorological station to the mine is the Jabiru Airport Station, located 2.7 km away.

In the Darwin region there are three seasons that include a wet season, cyclone season and a dry season (BOM, 2016a; Moise et al., 2015). The mean temperatures in this region have increased between 1.0 °C in the north east and 0.9 °C in the north west, for the period 1910–2010 (Moise et al., 2015). A warming tendency is expected with *very high confidence* in the future including an increase in minimum and maximum temperatures (Moise et al., 2015). In each of the RCP scenarios, increased average rainfall is expected at this location.

Extreme high temperature events are expected to increase in magnitude, frequency and duration (Moise et al., 2015) with *very high confidence* in all RCPs (Moise et al., 2015). Heavy rainfall intensity is expected to increase with *high confidence*, since a warmer atmosphere (in a warmer climate) can retain more moisture (Sherwood et al., 2010). However, the magnitude of this change has been estimated with *low confidence* (Moise et al., 2015). Cyclone intensity is projected to increase with *medium confidence*, but decrease in frequency (Moise