

# ENGINEERING TERRAIN EVALUATIONS – OPPORTUNITIES AND CHALLENGES OF THE ENERGY TRANSITION

Tom Casey  
Arup

## ABSTRACT

As traditional energy (oil/gas) companies and other investors look to develop integrated export-scale green hydrogen hubs and onshore renewable power generation, the vast open spaces of Australia, are being explored to unlock the abundant and reliable renewable energy resources (wind/solar), supporting our energy transition.

The Clean Energy Council of Australia reported <sup>1</sup> tens of billions dollars of large-scale renewable energy projects are under construction across Australia, with almost 40% of Australia's energy generation from renewable sources in 2023.

Renewables in Australia, both onshore and offshore, are shown to be reliable, affordable and sustainable. Australia is one of the windiest and sunniest countries on the planet and a large proportion of regional communities are reported to be supportive of developments with the right engagement, reaping the benefits of jobs, consistent income and local investment that comes with large scale projects. Combined with the prospect of pumped hydro power storage (PHES) and battery energy storage systems (BESS), discussions on requirements for “base load” and “firming” (by coal or gas fired power stations) are likely near obsolete.

The energy transition is a complex topic, and the physical constraints of our environment will have a significant impact.

### *Challenges of physical environment and simplifying complexity*

Many energy transition projects will be set across extensive, remote or minimally developed landscapes of varied terrain and geology; crossing innumerable natural features and obstacles, encountering a spectrum of complexity at surface and in the subsurface. Understanding of the range and significance of engineering constraints and cost drivers is key to early decision making on project feasibility, in pre-FEED/FEED assessments and in subsequent execution and operational phases.

Engineering Terrain Evaluations (ETE); methodical and multi-phased assessments, are performed with the goal to simplify and characterise the complexities of these vast sites into a spatial framework, defined by broad landscape areas (terrain units) with a consistent range of geological and terrain conditions. Each terrain unit can be considered as a single unit from a planning or costing perspective, defining significant engineering constraints and cost drivers.

In simple terms, the principal purpose of an ETE is to identify sources of geohazard risk and evaluate the implications for project feasibility, site selection/suitability and high-level inputs to layout optimisation. This approach represents best practice approach when considering assessment of large-scale sites; and helps inform both SME and non-technical parties within owner/developer organisations.

The challenge for studies on such projects is rarely to do with managing large volumes of information and data, as many are remote locations with sparse site observations, limited to no detailed records (bores), topographic surveys and mapping. Rather, it is the need to determine the range of anticipated characteristic conditions, by extracting key geological/geomorphological information from limited sources and reliance upon expert judgement/experience of engineering geologist/geomorphologists. Knowledge and experience in this context is invaluable.

### *Recent experience*

Recent project experience in Western Australia (Pilbara), South Australia (Eyre Peninsula) and Queensland, considered power generation sites of several thousand square kilometres and/or linear infrastructure corridors extending of many hundreds of kilometres. All projects adopted a broadly consistent approach to the terrain evaluation, which resulted in clear, concise and actionable advice, informing technical and commercially driven aspects of projects and client teams.

Initial screening established those geohazards that may be significant for power generation plant (wind turbine and solar arrays) and associated infrastructure/facilities, including roads, cables and pipelines within power generation envelopes. Simple hazard-risk models were then developed to identify how these geotechnical hazards (‘geohazards’) can lead to specific adverse consequences.

Preliminary terrain classification (mapping) was generally guided by two main factors; (i) topography; defining surface geomorphology and terrain ruggedness; and (ii) geology, defining the shallow sub-surface conditions. These two factors

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<sup>1</sup> <https://cleanenergycouncil.org.au/advocacy/industry-snapshot>

can be considered in terms of relative complexity ratings, where topography was referred to as “Site Complexity”, and the sub-surface ground conditions, referred to as “Geotechnical Complexity”.

Site complexity reflects the constraints on layout of power generation plant and routing of access roads, buried cables and pipelines. In low relief/near level terrain, standard geometric grid layouts can be adopted, whereas in terrain of increasingly rugged, high relief and steep terrain, the impacts can be felt in the wind regime at site or could result in shading of PV.

Geotechnical complexity accounts for ground-related hazards and impacts upon foundation and subgrade conditions and can impose significant construction costs (cost drivers) requiring mitigation.

A simple five-class qualitative assessment (Low, Medium-Low, Medium, High, Very High) was made for the level of site and geotechnical complexity in each terrain unit defined, and points plotted on a matrix for ease of comparison.

The value in this approach is how it enabled differences in complexity between terrain units to be qualitatively rated or ranked, and understood in terms of broad impacts to both construction and maintenance cost (including investigation, design and mitigation costs) and the residual risks to which the project would be exposed. The difference is measured in terms of whether standard engineering considerations/solutions apply, versus requirements for special measures and more design and construction considerations or indeed zones to exclude/avoid.

This simple approach to defining the complexity of a site was most usefully applied to the large power generation envelopes and other development sites where layout was a critical design issue. This approach establishes a consistent framework for assessment of large sites/broad corridor complexity, it does not wholly address requirements appropriate to long linear infrastructure corridors (transmission), and specifically routing constraints for buried pipelines.

Subsequent studies targeted increased characterisation of threats to the project posed by indirect and/or temporal hazards, including extreme wind (tropical cyclone), fluvial flood, bush fire, seismicity, tsunami and coastal erosion. Studies further informed layout and routing constraints, mitigation measures for specific hazards, and identified requirements for detailed analysis/modelling or where design codes may be lacking. Material sourcing studies aimed to inform planning for construction material supply potential from local borrow sites and regional commercial supply.

Each stage of an ETE aims to minimise and characterise uncertainty; and to achieve this requires the right people, skills and expertise. These skills are core to experienced engineering geologists and geomorphologists. When deployed on projects in a timely manner, anticipated geohazards can be identified, managed appropriately and effectively communicated to decision makers, technical specialists and stakeholders, to achieve positive outcomes.

#### *Opportunities with the modern digital age*

The need for experienced people will never diminish, and the wealth of geospatial data currently available can present challenges in simplifying the complexities of site conditions into a meaningful framework for identification and management of risks. With the right experience, combined with state-of-the-art data analysis and application of AI/ML techniques, opportunities exist to provide repeatable outputs with greater insights. Much of the data used in recent projects was a rich mix of publicly accessible geospatial mapping (including geology) and digital elevation models (initially 1 sec SRTM data, and subsequently detailed LiDAR). Data which is widely used in common geospatial analysis.

Application of generative AI (e.g. Large Language Models) in geospatial analysis, is going to be a valuable tool in augmenting the desktop study process, but is unlikely to replace the human expertise factor, not yet anyway. As with any complex modelling or assessment process, the saying “rubbish in, rubbish out” remains true, in the absence of sufficient, quality data and inadequate understanding of the problem or conditions being considered.

Recent reports suggest that more than 90% of students are using AI to complete work; and whilst this approach may build perceived proficiency in using these digital tools, it is unlikely to build knowledge and deep learnings on the particular topic. The AI landscape is rapidly developing, reliability and accuracy will most likely improve, but there will remain elements of uncertainty that cannot adequately be predicted; and that will need application of expert judgement, based on years of experience, knowledge gathering, learning in the field and at the desk.

The importance of technical guidance, knowledge sharing and experience of global geohazard risk expertise is invaluable and it is clear that knowledge sharing and technical mentoring by senior industry expertise will be critical for development of future generations of engineering geologists (EG).

#### *Challenges of the professional landscape in Australia*

Skills and labour shortages are impacting the energy transition, and so it is imperative that industry advocates for the necessary skills and people. AI is useful, but it will not replace our jobs, yet.

Geologist remains on the Australian skills shortage list and yet geoscience and engineering geology undergraduate/post-graduate course are declining (globally) and so the supply of graduate/postgraduate geoscientists/EG's will follow.

Industry recognition and avenues for professional registration of geologists in the engineering sector in Australia are inadequate and likely contribute to the attrition of skilled geoscience expertise and resources.

The absence of an impactful route to professional registration/accreditation of geologists and recognition within the engineering sector critically undermines and devalues the skills and expertise of engineering geologists in industry. Particularly for those EG professionals in the early stages of their careers and who have not spent time overseas, notably in the UK or US.

The peak bodies, professional organisations and routes to professional registration in the UK and US, are a good examples of the type systems and professional pathways that promote application and collaboration of the diverse range of geoscience, engineering geology and geotechnical engineering skills, with relative parity of recognition. These pathways can always be better, but they are a good starting point.

In Australia, this critical gap and weakness in professional registration of EG's has influence beyond the sector/industry. Specifically, poor perception of geology within engineering sector as a long term career option, particularly for the generation currently in the tertiary education (if they even know of it as an option).

Persistent historical perceptions of geology and careers in geology across the Australian education system, appear somewhat skewed towards those of mining/mineral extraction and hydrocarbon industries; those typically of adverse environmental impact and significant contributors to climate change and global warming. Some of these industries continue to play a vital part in society of today; however, it is clear that things must change, and the younger generations are becoming more vocal on the urgency for change.

Unfortunately, awareness of alternative careers and the valuable role of geologists in supporting society, protecting it from the impacts of natural hazards is poor <sup>2</sup> (Australian Geoscience Council, Project Geoscience survey).

We have seen the impact of this poor perception and awareness playing out in recent times, with closure of distinguished, long standing geoscience and engineering geology undergraduate/post-graduate courses in Australia, New Zealand and the UK. The reasons are multifaceted, both commercially driven and reducing enrolment, but the result is the same, severe impact to the supply of trained geoscientists available to industry in support of the ever-increasing geohazard challenges.

For a continent which faces increasing severity and incidence of climate and weather-related geohazards; the society and built environment are encroaching into ever more remote and challenging terrain (both onshore and offshore); the pressures of increasing population and urbanisation, and developments pushing into poorer and potentially more adverse terrains; the need for more experienced engineering geologists is ever more critical to manage risks that come from this friction of natural hazards, human made risks and potential disasters.

#### *Where to from here?*

The diverse range of skills required to tackle geological and climate related threats to society and communities worldwide, should be an easy theme to promote to younger generations. Early STEM engagement in schools is critical to developing awareness and enthusiasm required to prime interest for tertiary studies/training and into professional practice. Some are making efforts in this space, but more is required.

The growth of digital skills, AI technology and application to such engineering studies for energy transition projects described, present a unique platform to influence perceptions and engage interest of younger, more digitally savvy generations in the range of rewarding careers in engineering geology and broader geosciences.

Whether future generations of geoscientists come into the engineering by chance or by choice, the industry in Australia must improve the environment into which they come, and provide meaningful pathways for professional recognition.

As we are all keenly aware from our professional practice of the geosciences, the past is the key to the future and we must learn and act for the benefit of all, or face the consequences.

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<sup>2</sup> <https://www.agc.org.au/wp-content/uploads/2025/02/Fiftyfive5-AGC-Project-Geoscience-SUMMARY-19122024.pdf>