Despite a growing number of successful implementations of renewable energy projects at mine sites in Australia, the adoption of renewables in mining is still a niche market. While some factors drive the move towards renewable energy technologies in mining, a range of challenges inhibit technology diffusion. Research conducted at QUT’s Centre for METS Business Innovation, in collaboration with CRC ORE, has analysed the innovation system surrounding renewable energy technologies in mining – and identified a range of driving and impeding factors.

### Driving factors

- **Availability of public funding for initial projects**
  
  Initial funding for early-stage projects was primarily provided by the Australian Renewable Energy Agency (ARENA), thereby de-risking early experimentations. This enabled the realisation of initial projects and facilitated knowledge gains about adapting renewable energy technologies to the mining context. ARENA proactively shares knowledge, diffusing it across the industry. Successful projects have increased trust in renewables and attracted further funding.

- **Mine site remoteness and off-grid settings**
  
  The specific location and conditions of remote mine sites off-the-grid positively influence the development of new projects, for example, to overcome challenges and costs related to diesel supplies.

- **Collaboration between mining and energy sector**
  
  Cross-sector collaboration fosters experimentation with new applications, the launch of new projects, learning from projects and challenges, sharing of knowledge, and helps to mobilise financial and human capital.

- **Opportunity to develop transferrable knowledge**
  
  The specific requirements and conditions of the mining context present opportunities for energy providers to experiment with specific challenges and to develop knowledge which can be transferred to other markets.
Impeding factors

**Early-stage niche market**
An early-stage niche market with under-developed value chains and knowledge gaps can negatively affect the choice to participate in the market. Stakeholders and investors are hesitant to mobilise resources, technological legitimacy is limited.

**Perceived risk of implementing renewable energy technologies**
Risk perceptions, especially in a risk-averse industry such as mining, can negatively affect the choice towards a particular technology. Perceived high risks also restrict a technology's legitimacy.

**Knowledge gaps related to integrating renewable energy systems in remote locations in hybrid configurations**
Knowledge gaps negatively affect the deployment of new projects. A lack of real-world applications constraints opportunities for developing new knowledge, and thereby affects technological legitimacy.

**High costs of battery storage**
The costs of batteries affect the scalability of projects, limiting applications to small scale projects and limiting knowledge development for larger systems.

**Harsh environmental conditions**
Challenges to install solar PV and other renewable energy technologies in harsh environmental conditions of remote mines can prevent firms from doing so. These challenges also influence the legitimacy of these solutions.

**Short lifespan of a mine site**
A short remaining lifespan of a mine reduces the viability of renewable energy technologies due to high capital costs, restricting opportunities for new projects and market expansion.

**Silo mentality**
Project details, failures and challenges are often not shared openly due to a competitive environment, limiting the opportunities for knowledge flows across the innovation system.

**Small scale of projects**
To date, many projects have a small scale, limiting their attractiveness to some energy companies, and hence, reducing financial and human capital mobilised.

**Complex contractual and tendering requirements**
Complex and long-lasting tendering processes can act as a deterrent to energy providers, potentially limiting the number of firms active in the niche market, and resources made available.

**Resource constraints of energy providers**
Smaller firms are often resource-constraint, reducing availability of human capital to adapt renewable energy systems to new contexts, resulting in less opportunities for experimentation, knowledge development and knowledge sharing. Constrained financial capital can limit the ability to raise funds for new projects.

**Resource constraints of mining firms**
Smaller mining companies can be reluctant to consider renewable energy technologies due to limited resources for investing in non-core business activities and limited in-house knowledge, limiting opportunities to experiment with new energy projects.

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