Renewable energy generation has increasingly become a topic of interest for the Australian mining industry. After initial pilot and demonstration projects, more and more solar and wind plants are being installed to power mine sites across Australia – often in remote locations without access to the grid. But what drives this trend? What processes are necessary to increase technology adoption, and for the niche market to eventually expand? Research conducted at QUT’s Centre for METS Business Innovation, in collaboration with CRC ORE, has analysed the technological innovation system around renewable energy generation in mining. An innovation system analysis assists with evaluating a range of key functions of an innovation system and how they affect each other – allowing insights into the strengths and weaknesses of an emerging innovation system.

How do key functions of the innovation system affect each other?

In the Australian mining sector, the decision to implement renewable energy projects is driven by the need of mining firms to reduce operational costs associated with energy generation while at the same time decarbonising their energy consumption (F4). This aspiration leads to mining companies and energy providers deploying renewable energy systems at mine sites, and thereby initial projects emerging (F1).

Given that the application of renewable energy technologies in the context of mining is in its early stage, there is a significant need for knowledge development (F2) and knowledge sharing (F3), which as gained, has increased the legitimacy of these technologies for mining applications (F7). When the first renewable energy systems were installed at Australian mine sites there was uncertainty around the feasibility of integrating renewables into mining settings. Therefore, resources (F6) - in the form of government incentives - were required to contribute to the high upfront costs and to de-risk the projects. With an increase in the number of projects, associated knowledge developed (F2) and growing trust in the technology (F7), the need for government funding decreased over time. The availability of initial incentives was substituted by green funds and private investments, covering the still high initial costs of renewable energy projects (F6).

Funded renewable energy systems were deployed through the collaboration between mining companies and energy providers (F1). This collaboration and business transaction has been enabled by a specific form of contracting; the power purchase agreement (PPA) (F5). PPAs were originally developed for utility level renewable energy projects and had to be adapted into corporate PPAs for the specific off-grid applications at mines. Therefore, the understanding of corporate PPAs has been tightly connected with the deployment of new renewable energy systems (F1), where the successful deployment of a new project has also led to a better understanding of how to structure and use PPAs. Positive outcomes of these dynamics feed back into the development of the innovation system as they provide incentives for other actors to initiate projects.

What are the key functions of technological innovation systems? ¹

F1 Entrepreneurial Experimentation concerns the exploitation of new business opportunities based on new knowledge, networks, and markets; often through trial-and-error experimentation. Examples of entrepreneurial experimentation include pilot plants with the aim to commercialise a technology or adapting it to different applications and user contexts.

F2 Knowledge Development focusses at R&D and knowledge development activities related to a particular technology group. Examples include research projects and programmes, patents, or technology acquisitions.

F3 Knowledge Diffusion captures the extent to which new knowledge is shared and exchanged through the networks of an innovation systems. This is often evidenced by research collaborations, conferences, workshops, or organisations stimulating the exchange of knowledge.

F4 Guidance of the Search represents selection processes among technological options and specific wants and needs of stakeholders guiding the system into a particular direction. This can include policies, government roadmaps, strategies, problems that need to be solved, or joint visions across an industry.

F5 Market Formation relates to the creation of new markets for a new technology, often starting with smaller niche markets before a new development diffuses into the mass market. The state of a market is typically evidenced by sales or installation numbers, while the presence or absence of demand articulation and market-stimulating policies can indicate the prospects of a new market.

F6 Resource Mobilisation captures the quantity and quality of financial and human capital allocated towards development, diffusion, and market formation activities. Research and public funding play an important role for this function, as do investments by firms, the availability of research infrastructure, and appropriate training and education of staff.

F7 Legitimacy concerns advocacy for a new technology and activities to counteract potential resistance to change towards new technological solutions. Independent assessments by experts and support from industry associations can play a role for creating legitimacy, as well as successful demonstration projects.

F5 to F1 - Collaboration between sectors:
The collaboration between the mining and the energy sector, including energy partners and consulting firms (IPP, engineering firms, renewable energy systems developers) is an essential dynamic element of this innovation system. The successful deployment of renewable energy systems relies on energy partners with sufficient knowledge to meet the needs and requirements of mining houses (F6 – human capital). This collaboration is supported by the availability of PPAs, which is therefore the main transactional instrument to support market formation activities (F5).

F4 to F1 - Why mining companies are interested in renewable energy technologies:
The mining industry started to investigate renewable energy technologies because of the pressure of rising energy costs and the need to address GHG emissions from mining operations – this guided the search towards potential solutions and technological choices (F4). The need to address rising energy costs and GHG emissions from mining operations was identified by interviewees as the main reason for the mining industry to investigate renewable energy. The challenge to find a solution to costs and emissions led mining companies to investigate renewable energy technologies, since these technologies are mature, well known and understood and have been successfully adopted in other industries to address the same problem.

F2/3 to F7 - Knowledge gap of renewable energy in mining:
Although renewable energy systems in general are well understood, installing them in remote locations, integrating them into existing energy systems and matching them with 24/7 mining operations is still not well documented (F2/3). Issues concerning the intermittent nature of renewable energy technologies have emerged as a key challenge, which is manifested as poor institutional alignment between the technology considered and the power requirements of the mine sites (F7). The need to better understand the role of renewable energy in mining led to a series of trials and preliminary studies, with installations across Australia (F1). The scope of these installations was to test the feasibility of using renewable energy to reduce the dependency of mining operations on fossil fuel sources, and to develop a better understanding of the integration of renewable energy in this sector (F2). The knowledge developed in the early projects has been shared across the industry by ARENA and via various media channels (F3). The success of early projects has increased the technology’s legitimacy in the mining sector and has led to a reduced perception of risk around renewable energy (F7). Eventually, this has motivated the installation of new systems without depending on incentives such as from ARENA (F1).

F7 to F6 to F1 - Government incentives and PPA:
Due to the remote location of many mine sites in harsh environments and their specific energy requirements, initially the available knowledge of renewable energy systems was not sufficient to reduce the perceived risk around renewable energy as a reliable substitute energy source (F7). In 2011, the first system in Australia was deployed under a PPA over 5 years. While this first system paved the road to renewable energy in mining, it was not until 2016 that a second system was deployed. Since the establishment of the Australian Renewable Energy Agency (ARENA), which was born from the need to accelerate the pace of pre-commercial innovations reducing GHG emissions, the number of systems has increased (F6). ARENA was therefore an important stakeholder in the initial phase of the market formation that enabled the deployment of new systems (F1), provided funding (F6) and supported knowledge development and diffusion (F2, F3). Today, green leasing finance has been identified as a common way to obtain initial capital to realise renewable energy projects. The legitimation of renewable energy in mining has therefore enabled the availability of additional resources (F6) and hence, the realisation of new projects (F1).

F1 to F2/3 to F7 - Knowledge gap of renewable energy in mining:
Want to learn more?
Visit our website to learn more about the dynamics of innovation processes of renewables in mining and their impacts using our interactive online tool.

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