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Driving toward tomorrow: Cost dynamics of hydrogen-powered trucks and infrastructure in Australia

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This study delves into the cost of owning hydrogen-powered trucks and their associated infrastructure in Australia. It extends its focus to the Total Cost of Ownership analysis for medium-duty and heavy-duty trucks, encompassing diesel, battery, and fuel cell powertrains, with projections stretching until 2050. These hydrogen fuel cell trucks hold the potential to slash emissions by up to 5,000 tonnes of $CO_{2\text{-}e}$ per transport unit during their operational lifespan. The study anticipates cost parity around 2030, particularly for long-haul freight, envisioning hydrogen fuel cell trucks as the singular cost-competitive choice by 2050. Presently, zero-emissions powertrains incur a 25-35% cost premium in the medium-duty sector and up to 70-119% in articulated trucks compared to their diesel counterparts.

Additionally, the study focuses on the cost of owning hydrogen refuelling infrastructure for varying on-site and off-site hydrogen production combinations. This analysis considers hydrogen refuelling station demand spanning from 200 to 4,500 kg/d. For daily commutes of six trucks from Perth to Port Hedland, a minimum of five refuelling stations are needed, with an associated infrastructure cost of $13 million. Furthermore, should the entire trucking sector in Western Australia and the broader nation transition to hydrogen, it would necessitate the establishment of 300 and 2,500 refuelling stations, each boasting a 4,500 kg/d capacity.

The levelised cost of hydrogen varies significantly based on refuelling station demand, with lower rates for higher demand. Off-site hydrogen refuelling station configurations require a lower initial capital investment but lead to a higher levelised cost of dispensed hydrogen. Conversely, strategically locating on-site refuelling stations within major hydrogen production hubs offers advantages in terms of the initial investment and the levelised cost of hydrogen. However, this approach may introduce challenges related to flexibility as the hub locations predetermine refuelling station placement.

The energy transition and sustainability: are we disregarding intergenerational equity?

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As the energy transition gathers momentum, some nations, such as Australia, are hurtling at a breakneck pace to install many gigawatts (GW) of new electrical capacity in a short period of time. As observed in Queensland, the installation of solar capacity is being done in less than one third of the time that it took to commence the coal seam gas industry, with concomitant impact on society, soil, and farming. Such speed of activity occurs without a well-developed regulatory framework for operations, grid connection, integration with the existing network, or decommissioning.

Focusing on solar energy, concerns have been raised in academia and government that the breathtakingly fast rate of solar installation is at the cost of sustainability, with fundamental principles of sustainability being ignored in order to meet renewable energy targets. These targets are usually either binding *Nationally Determined Contributions* under the Paris Agreement, or legislated targets such as that set out in s10(1)(a) of the *Climate Change Act 2022* (Cth), which requires Australia to reduce its greenhouse gas emissions to 43% below 2005 emissions levels by 2030.

Drawing upon previous research in sustainability and energy, this paper will analyse whether the implementation of mandated targets disregards the principles of sustainability. In particular, the paper will focus on the rapid implementation of solar energy, examining legacy issues such as child labour, mining and use of critical minerals, waste generation from failure to plan for decommissioning, recycling and disposal of solar panels, and the impact of solar farms on future land use. This paper analyses these issues within the context of intergenerational equity, one of the fundamental cornerstones of sustainability, to determine whether intergenerational equity is disregarded in the race to meet mandated targets.

Sharing learnings from Australia's only non-commercial Wave Energy demonstration project – the M4 in Albany, WA

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Supported by the WA Government's 'Royalties for Regions' scheme, The University of Western Australia (UWA) established a new knowledge hub in marine renewable energy with headquarters at its regional university campus in Albany on the WA south coast in 2018. This knowledge hub operates as Marine Energy Research Australia (MERA) out of the UWA Great Southern Marine Research Facility – now a recognised destination for ocean energy research, STEM education and community outreach. A new partnership between UWA, the Blue Economy Cooperative Research Centre and the WA Government is now funding an innovation project for a prototype wave energy converter in Albany's outer harbour. This demonstration project involves the design, manufacture, deployment, operation, and decommissioning of a reduced-scale M4 ('Moored MultiModal Multibody'), seeking to test and validate the infrastructure and supply chain necessary for emerging marine energy markets, including the aquaculture industry in the region. The M4 project is very complex and ambitious as it operates on a shorter timescale and smaller budget than commercial projects do, with a stronger academic underpinning of resource and site assessment, performance of the Power-take Off unit, and iterative nature of the regional business engagement.

Wave energy deployments are typically commercially sensitive and therefore difficult to build research and engagement programs around. In this case, data will be publicly available and benefits will include demonstration of local and national capability, interaction across sectors, advancement of the technology and community engagement. All "Lessons Learnt" including in environmental approval and permitting processes are being documented to support the marine energy sector in Australia and internationally. Albany is a superb location for this demonstration project as it has established regional university education and fieldwork capabilities, several potential wave energy development sites – from nursery to full-size conditions – that could attract technology developers to the region, and a tight-knit community of engaged stakeholders, including local Government and the Port. The M4 wave energy converter is ideal for this project as it is supported by the academic, non-commercial collaboration between UWA and the University of Manchester, and the technology has undergone extensive optimisation, with results published in peer-reviewed journals.

Enabling high PV penetration levels in low-voltage distribution networks using smart inverter control strategies

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Modeling, optimisation, and control of unbalanced three-phase low-voltage distribution networks (LVDNs) are crucial for the integration of substantial penetration levels of photovoltaic (PV) systems. A benchmark case study has been introduced to elucidate the challenges and gaps encountered at various penetration levels of PV integration in LVDNs, aiming to enhance the comprehension of the networks' behavior, thus fostering the advancement and validation of corresponding models and tools. An interface between OpenDSS and Julia is also crafted to illustrate the influence of diverse PV integration levels on aspects like inverter operations, active power curtailment, and voltage standards in LVDNs.

The findings spotlight several constraints and hurdles associated with the utilisation of prevailing smart inverter control strategies, touching upon aspects such as inverter performance, active power curtailment, and voltage standards. Challenges noted encompass over-voltage complications when applying the constant power factor strategy, significant active power curtailment in the volt-watt strategy, and elevated current flows and suboptimal power factors with the volt-var strategy. Moreover, contemporary system models have overlooked the inclusion of uncertainties affecting the performance of PV modules and have inadequately addressed the internal and standby losses experienced by inverters. Such omissions can lead to misconceptions regarding the actual influence of PV systems on LVDNs and miscalculations concerning the network's capacity to assimilate significant levels of PV integrations.