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# An international review of the implications of regulatory and electricity market structures on the emergence of grid scale electricity storage



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## ABSTRACT

Energy storage systems (ESS) have the potential to make a significant contribution to planning and operation practises in power systems. While ESS can be used to provide multiple benefits in the power sector, widespread use has been restricted by high technology costs, lack of deployment experience, and the barriers and uncertainties caused by the present electricity market and regulatory structures that were designed for conventional electricity systems. This paper reviews countries with high renewable targets and with significant current or planned ESS deployments to ascertain the common problems affecting the use of ESS on the grid, and to establish where changes have been made or proposed to the electricity market and regulatory frameworks. Three major problems were identified as the undetermined asset class for ESS and unbundled electricity system limiting stakeholders from determining and realising multiple ESS benefits; low electricity market liquidity and changing market conditions; and a lack of common standards and procedures for evaluating, connecting, operating and maintaining ESS. Based on the established barriers, recommendations to update or create policies, regulation and market arrangements to increase the viability and wider use of grid level ESS are discussed. The three key regulatory and policy recommendations were identified as an alignment of renewable policies to that of ESS; creating a separate asset class for ESS and associated rules for regulated and competitive operations; and standardising assessment frameworks, connection and operational procedures for the use of ESS. Finally, three main electricity market recommendations include updating rules to support simultaneous ESS operation across wholesale, ancillary services and capacity markets; updating market rules to allow compensation for flexible and highly accurate responsive demand and generation technologies, such as ESS; and updating market ancillary services energy requirements.

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## 1. Introduction

### 1.1. The evolving power sector

Electricity is crucial to the development, progress, security and overall lifestyle in the global economy. Industrialisation led to the construction of large power plants in central strategic locations to generate and supply power through transmission and distribution

networks (T&D) to consumers [1]. Globally there is at present a great reliance on these large fossil fuel or nuclear power plants to provide electricity needs [2]. The global power sector is facing or anticipating changes brought about by factors which include a growth in electricity demand; ageing electricity infrastructure; increase in the adoption of variable and flexible low carbon technologies (such as wind energy, solar photovoltaics, heat pumps and electric vehicles) and the need to integrate such

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