Chapter 8
Blockchain Applications in the Energy Industry

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ABSTRACT

The current energy transition from a fossil-fuel-based economy to a zero-carbon has significantly accelerated in recent years, as the largest emitters have committed to achieving carbon-neutral goals in the next 20-30 years. The energy industry transition is characterized by modernization through digital technologies, increased renewable energy generation, and environmental sustainability. Blockchain technology can play a significant role in providing secure digital distributed platforms facilitating digitization, decarbonization, and decentralization of the energy systems. Several promising blockchain applications in the energy sector are under research and development, including peer-to-peer energy trading; carbon monitoring, management, and trading; and IoT-enabled electric grid management. However, several challenges are slowing down the commercialization of these applications, including outdated legislation and regulations, slow pace of adaptation from the traditional energy industry, and risks associated with the new, untested technology.

INTRODUCTION

This chapter begins with a summary of technological advances and paradigm shifts in the blockchain industry over the past two decades. To illustrate, recent advancements in technology enable interoperability between different blockchains, which negates the earlier view of a general-use blockchain network, thus, actualizing a world with multiple specialized interconnected blockchains. In addition, this chapter discusses the impact of emerging blockchain commercialization on different industries, especially the energy industry. To facilitate this discussion, we provide a brief overview of the global energy transition and its disruptive impacts on the traditional fossil fuel industry. Further, we explore the role that block-

DOI: 10.4018/978-1-7998-7927-5.ch008

chain technology could play in this transition towards more sustainability. Finally, the chapter examines current implementations, use-cases, and potential futuristic blockchain applications in the energy industry. We explore select applications in detail. In summary, this chapter aims to advance knowledge of these pertinent topics, given that blockchain is expected to have a foundational role in the future of the internet.

BACKGROUND

Overview of the Global Energy Transition

The current energy transition from a fossil-fuel-based economy to a zero-carbon one, which effectively began in the early 2000s, has significantly accelerated in recent years, as the largest emitters have committed to achieving carbon-neutral goals in the next 20-30 years. To illustrate, the United States (U.S.) pledged U.S. carbon neutrality by 2050 (Biden, 2020), while China aims to go carbon neutral by 2060 (AP, 2020). In addition to national-level commitments shaping policy, market dynamics have pushed major oil producers to shift capital towards solar and wind as exhibited, for example, by BP's plan to increase its investment in low-carbon energy 10-fold to $5 billion a year by 2030, taking its renewable-energy capacity to 50 gigawatts (GW), from 2.5 GW in 2019 (McFarlane, 2020). Globally, fuel importing countries have been faster to transition compared to fuel exporting countries. However, the gap between average Energy Transition Index scores for countries in the top quartile and the rest is narrowing, reflecting a growing global consensus on the priorities and speed of the energy transition (World Economic Forum, 2020). Figure 1 illustrates the Energy Transition Index by country. This index is scored on a scale from 0 to 100 with the goal of benchmarking countries on the performance of their energy system, as well as their readiness for transition to a secure, sustainable, affordable, and reliable energy future. Key parameters included in index calculations range from measures of fossil fuel dependency to investment in new energy infrastructure as well as political commitment.

The energy transition has been effectively motivated by increases in emissions. In the Paris agreement, countries concerned with the current trend in carbon emissions set a goal to limit global warming to well below 1.5 ° Celsius compared to pre-industrial levels. However, a look at the global carbon emission trends over the last three decades reveals that the growth has been exponential (Figure 2). Most importantly, the contribution of the Energy Sector (shown in dark blue and green colors in Figure 2) is responsible for more than half of the total carbon emissions. Therefore, achieving the goal of the Paris agreement requires an urgent and immediate restructuring of the energy industry. This means a faster pace of transition from fossil fuels to renewable energy, developing and integrating new carbon capture utilization and storage (CCUS) schemes into our current energy sources, moving towards decarbonized power systems, and eventually achieving net-zero carbon energy production by 2050 (IRENA, 2018).

This Global Energy Transition, which is well underway, has two main driving forces: the emergence of renewables as alternatives to fossil fuel-based energy, and the growth of electric-based technologies, like battery-powered vehicles for transportation (Wood-Mackenzie, 2018). Currently, the power and transportation sectors account for 70% of global coal demand, 50% of global oil demand, and upwards of 30% of global gas demand (Wood-Mackenzie, 2018). Meanwhile, renewables (mainly solar and wind) currently account for 7% of the global power market (Wood-Mackenzie, 2018). Globally, unsubsidized wind and solar projects have become more cost effective than projects reliant on fossil fuel technologies. As a result, more systems are now integrating renewables (Wood-Mackenzie, 2018). It is expected that the