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Volume 1 – Concentrating Solar Thermal Power

Chapter 1 – Introduction

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Concentrating solar thermal power (CSP) has been proven for decades as a viable renewable energy technology that can provide clean electricity and long-duration energy storage for utility-scale applications. Over six gigawatts of CSP plants are in operation globally, and over three gigawatts are either under construction or in development. Today, CSP technologies are poised to contribute to the continued decarbonization of the energy sector.

Commercial CSP systems were first deployed in the United States in the 1980s (354 MW Solar Energy Generating Systems parabolic trough CSP), including more recent CSP plants with at least 1 GWh of energy storage (Solana Generating Station in Arizona and Crescent Dunes Solar Energy Project in Nevada). Despite these pioneering efforts, no new CSP plants were under construction or in development in the United States in recent years. The market requirements and policy drivers vary by region and has changed over time, resulting in sporadic development and growth in CSP. Recent market drivers and renewable portfolio standards in the U.S. have favored lower cost solar photovoltaics (PV) or wind energy. However, as renewable energy penetration onto the grid increases, the need and value for large-capacity, longer-duration storage is being recognized. Studies have shown that for longer-duration storage requirements (> ~6 hours), CSP and thermal energy storage may be less expensive than PV plus battery storage [1, 2]. In addition, CSP provides synchronous generation for the electrical grid, which can be advantageous over asynchronous inverter-based generation for increased grid stability. Hybridization of CSP with natural gas can also provide increased peaking capacity while drastically reducing reliance on fossil fuels [3]. In other countries, these findings and additional market drivers (e.g., the need to replace expensive and polluting diesel generators) have enabled additional opportunities and deployment of CSP globally.

Recent research and studies demonstrate the feasibility of using CSP to also produce high-temperature process heat (~300˚C – 1000˚C) for industrial and manufacturing applications such as cement and steel production, and solar fuels for heavy transportation. Heavy-duty transportation (e.g., ships, trains, planes) and industrial heating contribute to over a third of global energy consumption [4-6]. Decarbonization of the entire energy sector will be required to reduce greenhouse-gas emissions and achieve climate-change goals set forth in the international Paris Agreement. Through continued advancements in materials, components, and systems integration, CSP technology can be used together with other renewable and carbon-free energy technologies to meet these targets.

This first volume, Concentrating Solar Thermal Power, provides an overview of key technologies, principles, and challenges of CSP. Chapters 2 and 3 provide a review of solar resource, optics and principles, and Chapter 4 summarizes various collector designs. Chapter 5 reviews state-of-the-art and emerging receiver technologies for solar thermal conversion, and

Chapter 6 summarizes thermal storage technologies. Chapter 7 describes thermal-to-electric conversion and power cycles being used and developed for next-generation CSP. Chapter 8 provides a comprehensive summary of operations and maintenance requirements for CSP plants, and Chapter 9 discusses commercial CSP plants and markets around the world. Finally, Chapter 10 provides a summary of process heating applications for industry and district markets. We hope this volume complements the excellent work and books that has been previously documented on CSP technologies [7, 8].

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