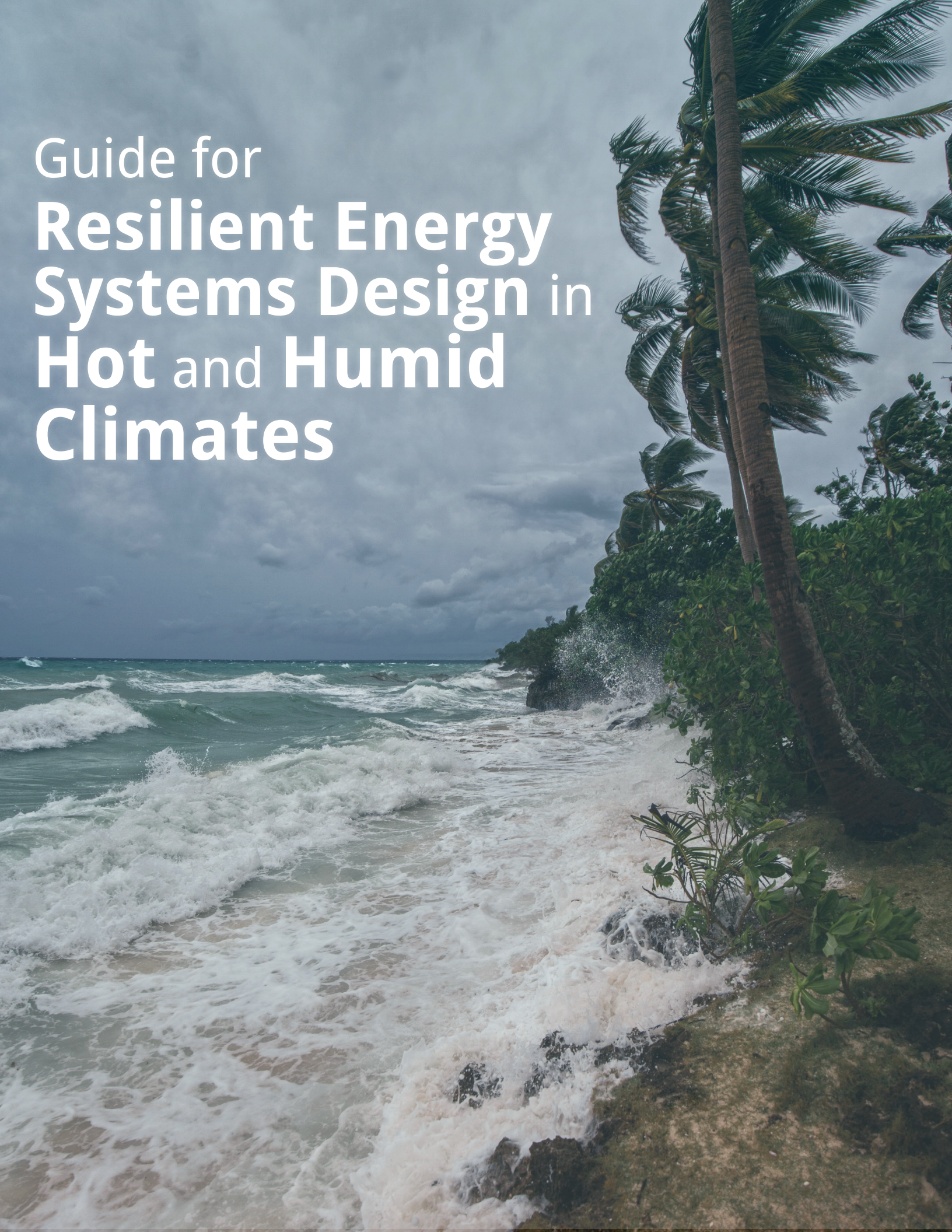


Guide for **Resilient Energy Systems Design** in **Hot** and **Humid Climates**

Guide for Resilient Energy Systems Design in Hot and Humid Climates

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Foreword

Resilience of thermal energy systems is critically important in extreme climates. While metrics and requirements for availability, reliability, and quality of power systems have been established (DOD 2020), similar metrics and requirements for thermal energy systems are not well understood despite a clear need in the earth's hot and humid regions.

Thermal energy systems addressed in this Guide consist of both the demand and supply sides. The demand side is comprised of active and passive systems including thermal demand by the process; heating, cooling, ventilating, and air-conditioning (HVAC) systems maintaining required environmental conditions for the building's operations and comfort for people; and a shelter/building that houses them. The supply side includes energy conversion, distribution, and storage system components. Requirements to maintain thermal/environmental conditions in the building (or in a part of the building) needed for housing critical mission-related processes and occupants include criteria to maintain thermal comfort and health, to support process needs, and to prevent mold, mildew, corrosion and other conditions that can damage building materials or furnishings.

During an ***emergency (black sky)*** situation, requirements of thermal parameters for different categories of buildings or even parts of the building may change. When normal heating, cooling, and humidity control systems operation is limited or not available, mission-critical areas can be conditioned to the level of thermal parameters required for supporting agility of personnel performing a mission-critical operation, but not to the level of their optimal comfort conditions during ***normal (blue sky)*** operations. Beyond these thresholds (habitable) levels, effective execution of a critical mission is not possible and mission operators must be moved to a different location. The Guide establishes these threshold limits of thermal parameters that may be in a broader range compared to that required for thermal comfort, but not to exceed levels of heat stress thresholds: in a cooling mode, the wet bulb global temperature (WBGT) in spaces with mission-critical operations should be maintained below 87.8 °F (31 °C) (ACGIH 2018).

Prescriptive guidelines for building energy efficiency in hot climates have traditionally been derived by a holistic consideration of climatic factors, energy policy, environmental policy, and economics. The differences in thermal barrier requirements in buildings across hot and humid regions of the world are influenced as much by the differing priorities of the governing bodies that set these requirements as they are by actual physical demands and conditions. Usually, national requirements for building envelope characteristics, e.g., thermal insulation values of its components, building envelope airtightness, vapor permeability, building mass, detailing, etc., are based on economic and environmental considerations. Thermal energy system resilience consideration brings another dimension to the optimization process of these parameters. The Guide summarizes best practice requirements pertaining to building envelope characteristics for buildings located in hot and humid climates of the United States, Republic of Korea, Japan, Singapore, Turkey, and several other countries; it also compares the effects of different levels of building envelope efficiency and building mass on indoor air temperature decay when cooling energy supply is interrupted.

Hot and humid climates present some of the most complex challenges for sustainable building design and operation to maintain high indoor air quality efficiently. Additionally, high temperatures, coupled with high humidity, create extreme comfort issues and exacerbate the potential for condensation, mold, and mildew.

Moisture control, or humidity control, is paramount in hot and humid climates. Currently, most humidity control strategies are based on relative humidity (RH) control. Extensive recent ASHRAE research has shown the benefits of controlling habitable space dewpoint, as opposed to RH, and indicated associated risks to the building above the suggested dewpoint threshold of 60 °F (16 °C). The Guide describes available control devices and subsequent building logic to control dewpoint efficiently while mitigating the potential for mold and mildew and to provide adequately conditioned supply air to satisfy the needs of space-conditioning efficiently.

Building materials in humid climates, especially in coastal locations, are also subject to rust and decay much more quickly than in other environments. In extreme situations, e.g., at Kwajalein or Okinawa, concrete elements of the building envelope break down and condenser units installed outside of the building envelope must be replaced within 2 to 3 years due to premature corrosion caused by a salt-laden ambient air. Additionally, many coastal areas located in hot and humid climates experience frequent tropical storms and hurricanes with associated heavy winds that can force water into the building and damage the building envelope.

This Guide is designed for energy systems designers, architects, energy managers, and building operators; it should prove a valuable resource for those who are involved in building planning and operation in hot and humid climates. This Guide, with its focus on the resilience of thermal energy systems, is meant to complement the ASHRAE Guide for Buildings in Hot & Humid Climates (Harriman and Lstiburek 2009).

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