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Modern Power Distribution Systems: Operation and Management Methodologies

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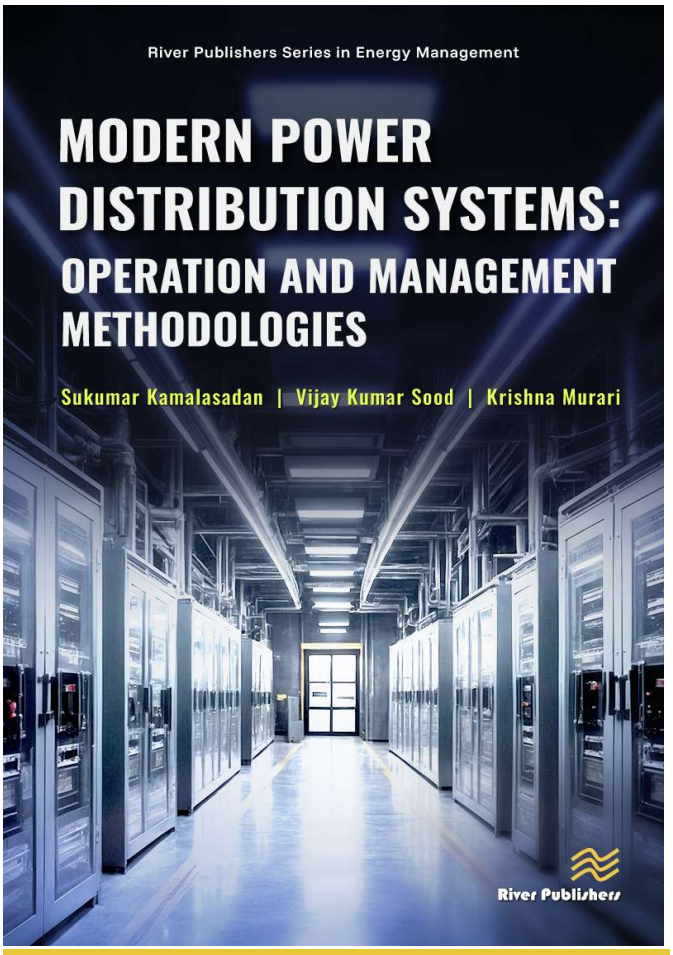

As power systems evolve from inertia-driven, synchronous generation to converter-based renewable energy, inverter-based resources (IBRs) are reshaping the modern electrical grid. This book brings together leading experts to provide a comprehensive and timely overview of IBR-based electrical distribution systems.

The chapters explore the rapid integration of solar, wind, and battery storage, and the critical role of power electronics and digital technologies in enabling a more sustainable and resilient grid. Key challenges—such as reduced system inertia and limited disturbance ride-through capability—are addressed alongside emerging solutions, including advanced control strategies, energy storage, and synthetic inertia through virtual synchronous generators.

Designed for both energy specialists and non-energy engineers, this book offers a clear and accessible guide to the principles and operation of next-generation distribution networks. It equips engineers, researchers, and technical managers with the knowledge needed to understand, design, and optimize modern grid systems in an era of increasing IBR penetration.

With its practical insights and forward-looking perspective, this volume is an essential resource for anyone working at the intersection of power systems, renewable energy, and smart grid technologies.

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Organizational inverter-based resources (IBRs), unbalanced distribution network, optimal power flow (OPF), centralized OPF, distributed OPF, equivalent network approximation, distributed energy resources (DER), PV bus, voltage stability margin, current injection load flow, dynamics of DERs, spectral clustering, resiliency, DER, active power grouping, microgrid, high impedance faults, fault detection, AC/DC distribution systems, grid-following inverter, grid-forming inverter

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