ELECTRIC POWER RESEARCH INSTITUTE

Renewable Resources and Integration

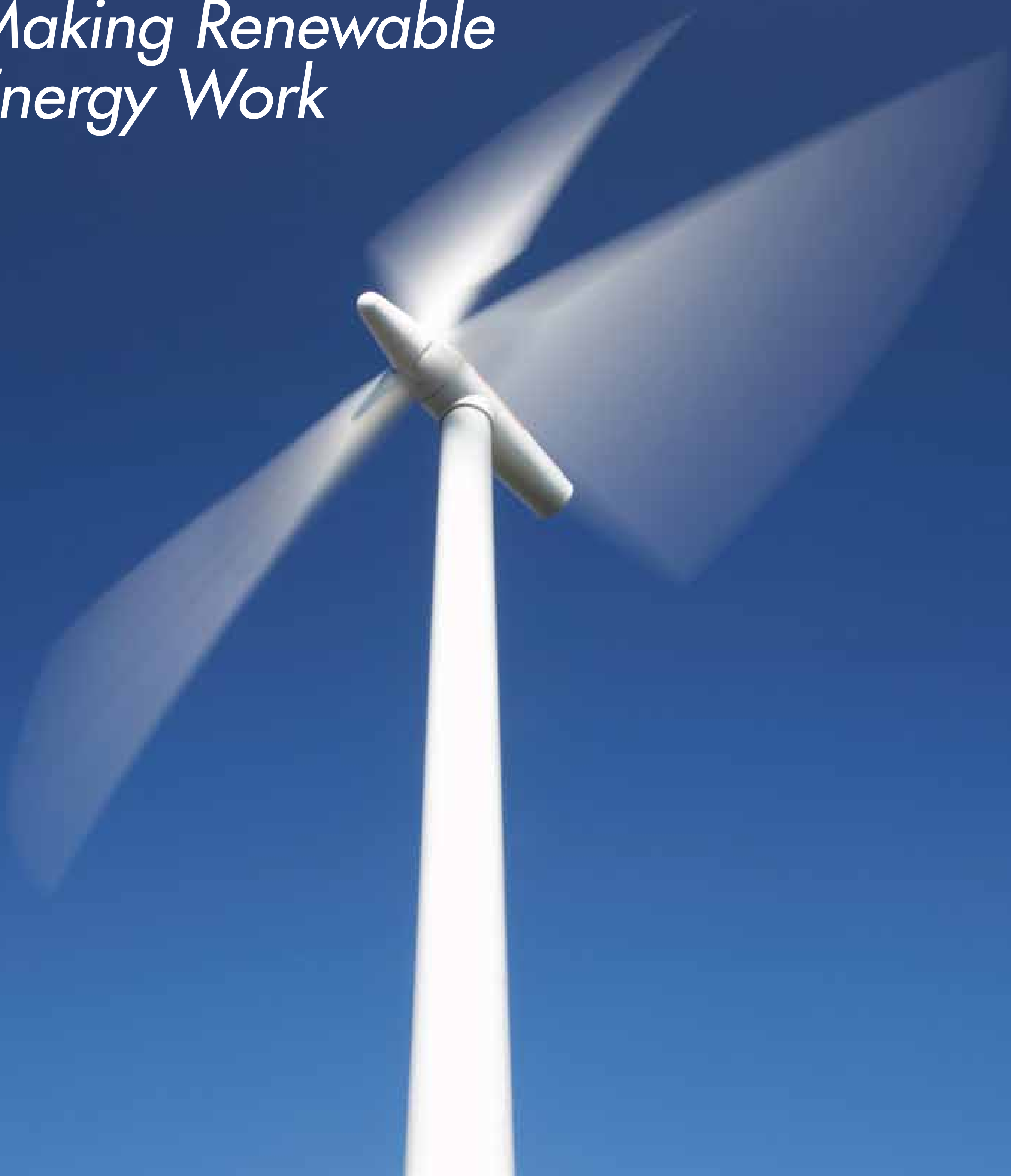
Executive Summary





Renewable Resources and Integration

Making Renewable Energy Work



A Changing Landscape

Renewable energy is fundamentally changing the electricity industry's strategic landscape. Renewables are the fastest-growing energy resource, and some projections indicate that by 2030, renewables could account for more than 20% of the electricity generated and delivered globally. Renewable portfolio standards, financial incentives, concerns over energy security, and efforts to reduce greenhouse gas emissions will continue to drive renewable energy deployment.

The growth of renewables poses three main challenges for the electricity industry:

- Enabling renewable generation technology options that are cost-competitive long term with other low-carbon forms of generation
- Maintaining electric grid reliability with high penetrations of variable wind and solar energy
- Understanding and minimizing environmental impacts of renewable energy resources on a large scale

Improving Renewable Generation Technologies

Today, renewable energy investments are highly dependent on legislative and financial incentives. Over the long term, it is clear that future renewable energy investment will depend on renewables operating cost-effectively without mandate or subsidy.

Research and development can improve the efficiency of various technologies in converting renewable energy resources to electricity. Improved operations and maintenance practices and technologies can reduce costs associated with utility-scale operations of renewable power plants. Up-to-date information is critical to explore new opportunities for the deployment, operation, and maintenance of renewable generation. Finally, targeted research and large-scale demonstrations are necessary to reduce the cost of renewable generation, improve overall reliability, and facilitate widespread deployment.

Building and Operating a System with Variable Resources

In some areas, variable wind and solar resources now account for as much as 25 to 50% of the instantaneous load served. System operators are accumulating first-hand experience with high levels of variable generation. These high levels have the potential to adversely affect the power system unless it is planned and operated differently than has been done in the past.

Additional transmission infrastructure will be required to move power from areas in which renewable resources are concentrated to the load centers. Also, transmission systems must reduce the overall variability by aggregating and averaging local variable generation over large geographic areas. System planning must expand beyond traditional service territories to work both regionally and inter-regionally. Capacity planning will need to cover not only maximum load scenarios, but also low- and shoulder-load scenarios that might present higher reliability risks than in the past.

It will also be necessary to increase the flexibility of the power system to respond to more variability and uncertainty. The potential exists for this flexibility to come from both conventional generation and new sources such as controlled smart charging of electric vehicles, energy storage, and additional system coordination.

Wind and solar generation resources themselves will have to provide flexibility, including the capability to limit ramp rates, curtail output when needed, and emulate other reliability functions such as inertia and frequency response that have traditionally been provided by synchronous generation. Distributed renewable resources will need to ensure effective management of feeder voltage maintenance and reverse power management.

Understanding Environmental Aspects of Renewables

Many proposed renewable energy projects have been challenged over concerns with potential environmental impacts such as land use, vegetation management, ecosystem changes, species displacement, or health and safety effects. In some cases, project developers have limited scientific information with which to respond to these challenges, creating permitting delays or cancellations.

For large-scale deployment, the industry requires a fuller understanding of economic and environmental impacts in several areas:

- Life-cycle analysis
- Sustainability and economic impact on competing uses of the resource
- "Sprawl" of generation installations
- Resource assessments and forecasting
- Species impacts and interactions

Such comprehensive understanding of environmental impacts might lead to guidelines and possible consensus for siting, stakeholder and public acceptance, and effective mitigation strategies.

Comprehensive Technology Research, Development, and Demonstrations

The EPRI RD&D portfolio spans renewable energy generation, integration and storage, and environmental aspects.

EPRI's generation research assesses the status, performance, and cost of renewable generating technologies (wind, solar, biomass, geothermal, and water) and offers technical comparison, selection, operation, and maintenance of these resources.

Renewable integration research addresses reliability impacts of renewable resources and explores the ways in which controllable load and energy storage technology can provide the flexibility necessary for managing variability. In addition, bulk storage such as compressed air energy storage can provide the ability to connect load and resources by shifting the resource or the load, creating additional flexibility in the way resources are scheduled.

Environmental research assists in the planning, siting, and operation of renewable energy infrastructure and addresses environmental and public concerns about the wide-scale deployment of renewable energy resources.

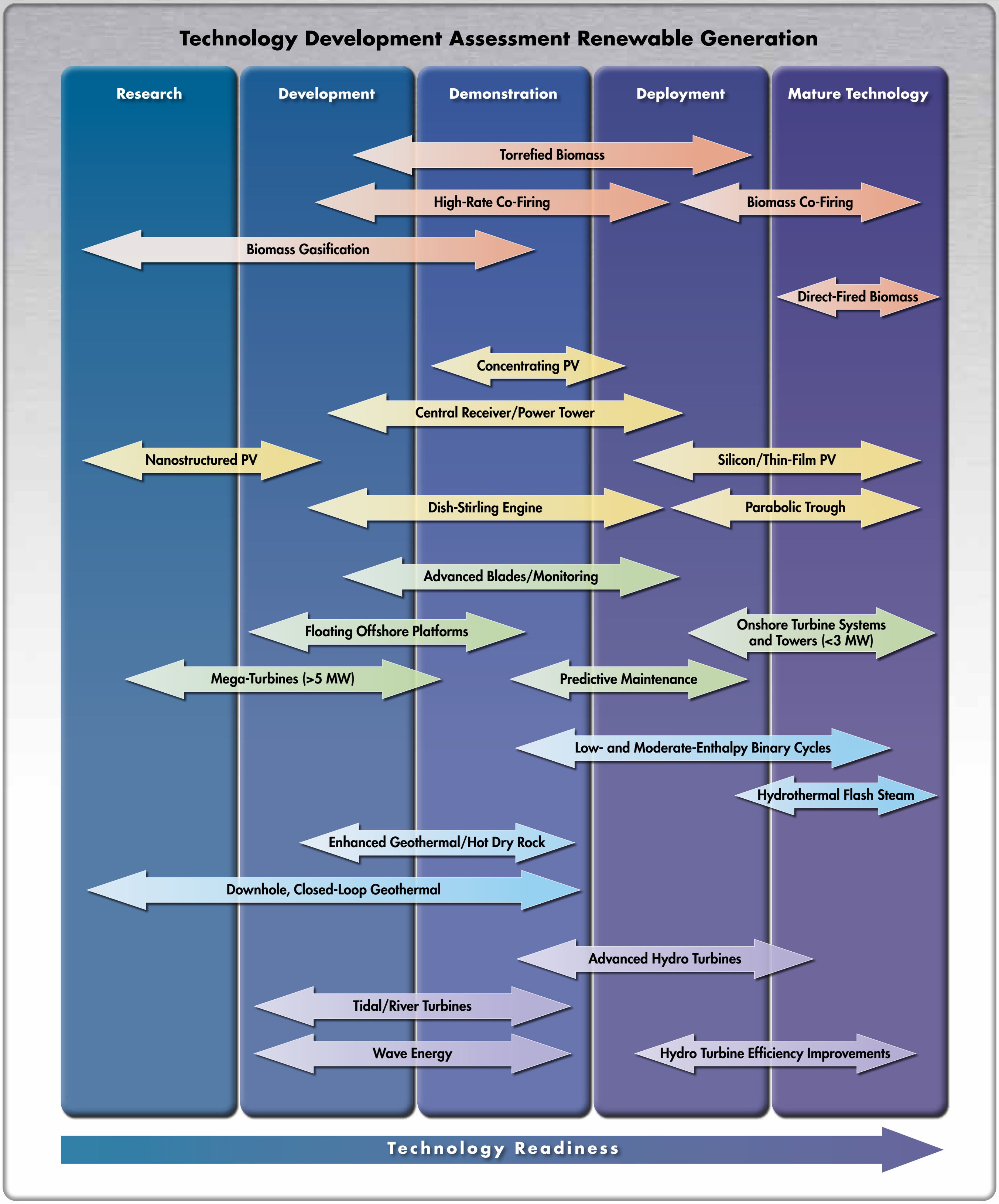
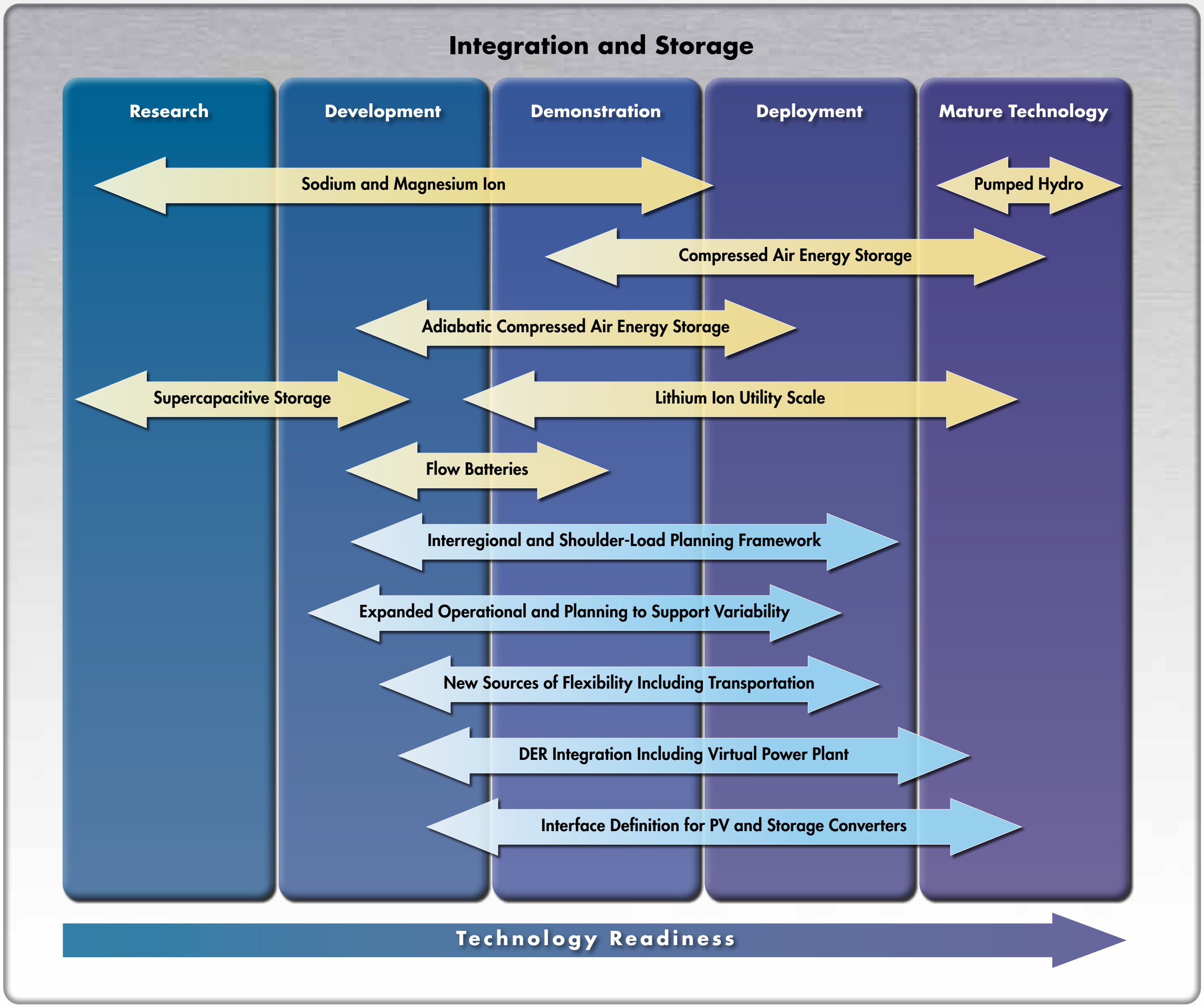

Technology Development Assessment Renewable Generation
Research
Development
Demonstration
Deployment
Mature Technology
Torrefied Biomass
High-Rate Co-Firing
Biomass Co-Firing
Biomass Gasification
Direct-Fired Biomass
Concentrating PV
Central Receiver/Power Tower
Nanostructured PV
Silicon/Thin-Film PV
Dish-Stirling Engine
Parabolic Trough
Advanced Blades/Monitoring
Floating Offshore Platforms
Onshore Turbine Systems and Towers (<3 MW)
Mega-Turbines (>5 MW)
Predictive Maintenance
Low- and Moderate-Enthalpy Binary Cycles
Hydrothermal Flash Steam
Enhanced Geothermal/Hot Dry Rock
Downhole, Closed-Loop Geothermal
Advanced Hydro Turbines
Tidal/River Turbines
Wave Energy
Hydro Turbine Efficiency Improvements
Technology Readiness

Figure 1 (left) illustrates the possibilities of renewable generation technology readiness from current status to estimates of 10 to 20 years out. It illustrates advancements in wind, solar, biomass, geothermal and waterpower required for successful large-scale deployment. Figure 2 (below) describes advancements in energy storage technologies and transmission and distribution integration development needed to support renewable energy as a sizeable, reliable and cost-effective percentage of the total electricity portfolio.



The Electric Power Research Institute, Inc.
(EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

Printed on recycled paper in the United States of America

1021531

3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com