U.S. DEPARTMENT OF
ENERGY

Office of
Electricity Delivery
& Energy Reliability

Advanced Grid Research and Development and H2@Scale

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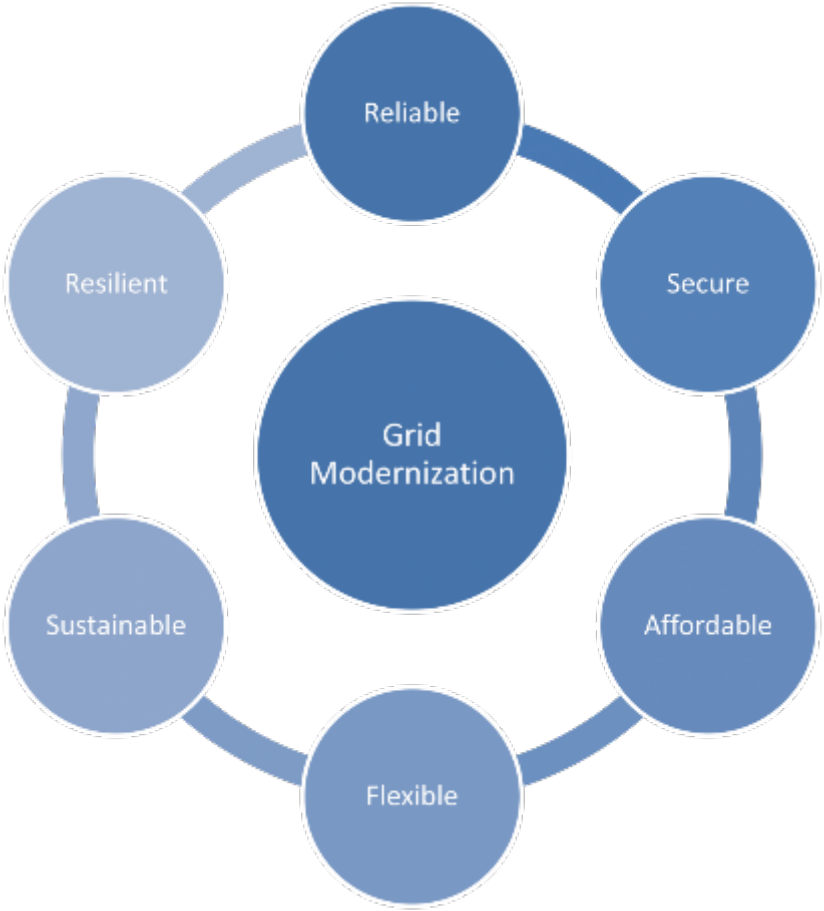
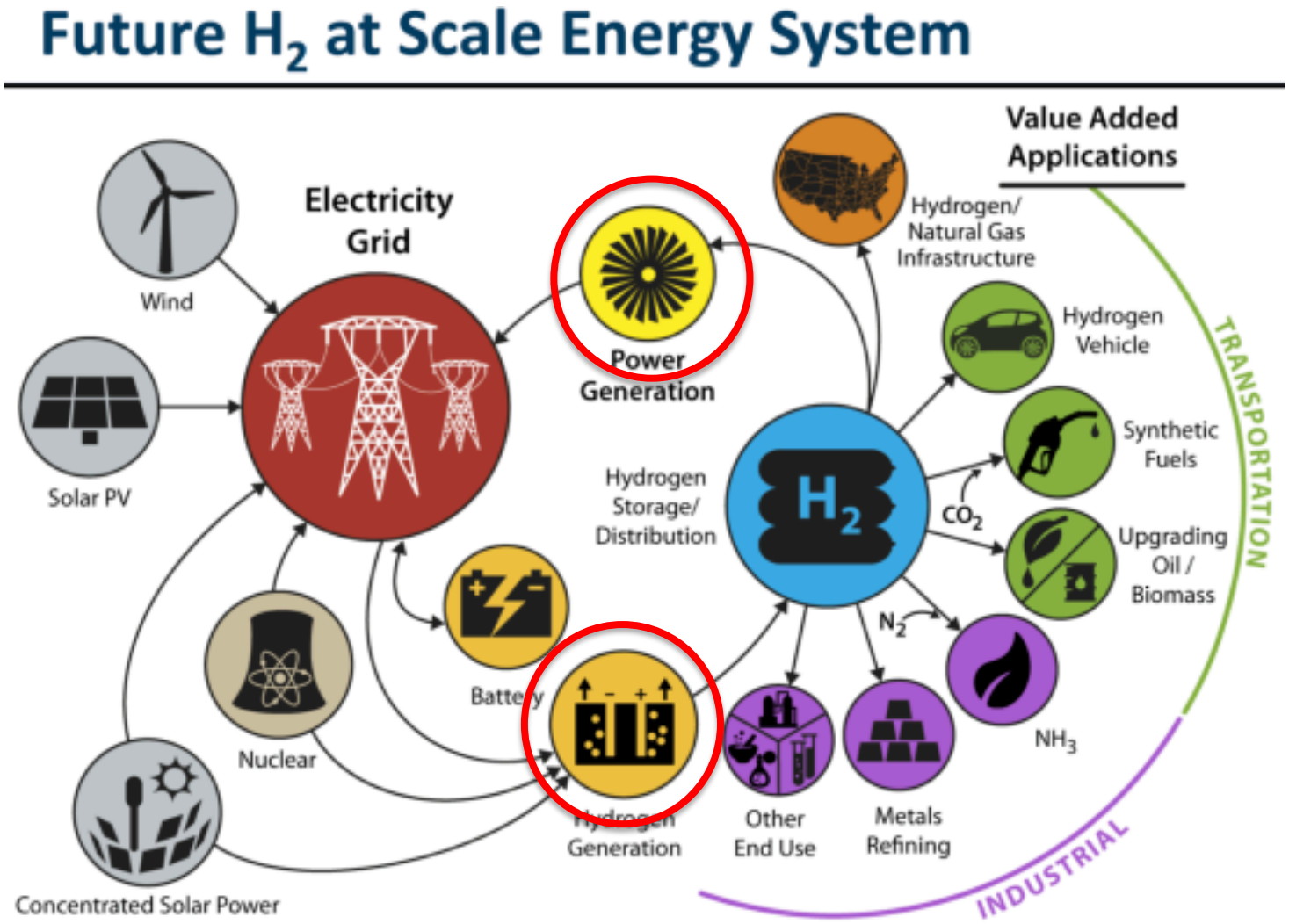
Modernized Grid Key Characteristics

- **Reliable**: Not prone to outage or disruption
- **Resilient**: Smaller scale and shorter duration of disruptions if/when they occur
- **Secure**: Able to survive physical or cyber attack
- **Affordable**: Delivered at an economically-competitive price
- **Flexible:** Actively to respond to the variability and uncertainty of conditions at various timescales
- **Sustainable**: Enabling cost-effective utilization of clean energy and energy-efficient resources.



H2 Ecosystem



Storage Economics and Policy Implementation

The Cost of a Storage System depends on the Storage Device, the Power Electronics, and the Balance of Plant

The Value of a Storage System depends on Multiple Benefit Streams, both monetized and un-monetized

Energy Storage Device 25-40%

Power Electronics 20-25%

Balance of Plant 20-25%

Advanced Grid R&D Programs At-A-Glance

Grid Communications and Controls	Smart Grid (SG)	Advanced Distribution Management System (ADMS) Microgrids Transactive Energy Sensors
	Energy Transmission and Reliability (CETR)	Advanced Synchrophasors Advanced Grid Modeling (AGM)
Grid Systems and Devices	Transformer Resilience and Advanced Components (TRAC)	Advanced Power Grid Components
	Energy Storage Systems (ESS)	Energy Storage Systems

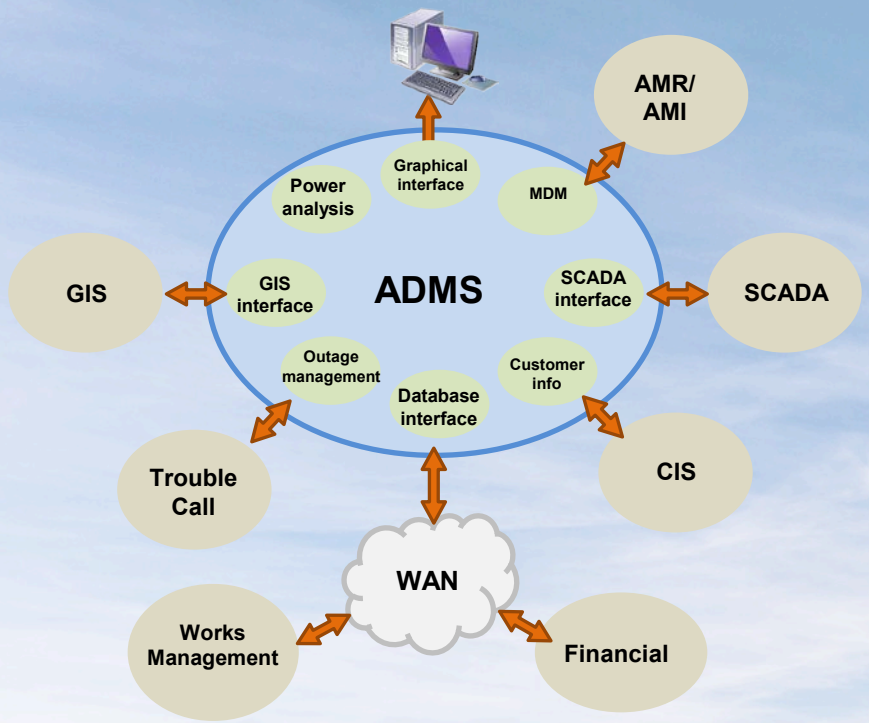
Energy Storage Program Objectives

Program Areas	Objective	Goals
Cost Competitive Technology	• Materials and chemistry • Systems and manufacturing • Cost reduction • Expanded applications	Capability and cost to meet industry requirements.
Reliability & Safety	• Lab testing • Codes and standards • Guidebooks • Certifications	User confidence and low liability
Regulatory Environment	• Policy analysis • Valuation methods • Resolution of benefits	Barriers and requirements equal comparable to other grid resources
Industry Acceptance through Demonstrations	• Stakeholder engagement • Proving success • Seamless integration • Consumer benefits	Sustainable progress

Microgrid Program Objectives

Program Areas	Objective	Goals
Cost Competitive Technology	• Microgrid controller • Tools development • Testing and validation • Standards	Meet end user needs for critical loads, power flexibility, reliability, and sustainability
Institutional Frameworks	• Peak shaving and provision of other grid services • Quantify cost and benefits	Support the macro-grid with handling and support of sensitive loads; provide ancillary services
Industry Acceptance through Demonstrations	• Intentional islanding • Grid integration • Enhance local reliability and power quality	Promote industry and customer participation and optimal use of generation assets
Resiliency Tools	• Response • Recovery	Optimize operations to achieve maximum resilience and reliability and provide uninterruptable services to the critical loads

Advanced Distribution Management System (ADMS)



ADMS develops an integrated software platform that enables integration of functionalities and applications across vendors for optimization and management of the entire distribution system, and will develop next generation applications to meet the future of the grid needs

ADMS Program Objectives

Requirement	Objective	Benefit
Platform	Develop open-source platform Connect to operational systems Framework for benefits evaluation	An open, interoperable platform for diverse users, developers, and stakeholders
Testbed	Span multiple vendors and management/data systems Integrate legacy and new	Speed integration and enable identification/validation of value
Applications	Develop initial application suite Baseline safety, resilience and reliability, and integration	Seed platform with valuable, market-ready applications to speed adoption
Advanced Control	Control theory and system architecture Scale to 10,000 DERs Validate performance	Ensures the complete integration of DERs as a core function
EMS/BMS/DMS Integration	Open framework for EMS/DMS/BMS integration Incorporate edge sensors Span spatial/temporal scales	Enable full, accurate, and useful view to “The Edge”

Advanced Synchrophasor Program Objectives

Requirement	Objective	Goal
North American Synchrophasor Initiative	• Realize promise of synchrophasor technology • Facilitate intelligent deployment of synchrophasors	Improve the electric power grid, improving reliability and efficiency of electricity delivery system
Advanced Application Development	• Automatic switchable network for reliable early warning for informed remedial reaction • Reliability monitoring and NERC compliance tools • Oscillation behavior	Enable wide-area measurement, monitoring management and control of electricity delivery system
Reliability and Models	• Research, develop, and implement electricity infrastructure and market simulations	Ensure electric reliability and improve efficiency and economics of markets
Measurement Devices	• Data quality • Device calibration (NIST) • Micro PMUs at distribution level	Sustainable progress

Advanced Grid Modeling Program Objectives

Requirement	Objective	Benefit
Data Management & Analytics	• Facilitate data standards • Create an environment for data sharing • Build capability at scale	High quality, accurate data
Mathematical Methods & Computation	• Increase pace to information • Reduce computational strain	Reduce barriers to data employment
Models & Simulation	• Rapid • Accurate • Precise • Interfacing	More useful, predictive information
Operator Tools & Decision Support	• Human interface • Application development • Adoption	Tools that deliver real-world value

Transactive Energy Program Objectives

Requirement	Objective	Benefit
Policy and Market Design	• Continued reliability • Understand volatility of generation and demand • Varying timescales and cost effectiveness	Fair and transparent energy market to support grid reliability
Business Models and Value Realization	• Understanding of customer value streams • Understand DER transactions	Greater proliferation of DERs and volume services
Conceptual Architecture Guidelines	• Clear structure • Establish traditional and distributed interfaces	Navigate a seismic shift in regulatory, business and technology domains
Strong Interfaces and Partners	• Enhance intra-grid information and value flows • Ensure “docking” with critical partners at the grid edge.	Interoperability that minimizes integration cost and maximizes asset utilization

Advanced Components Program Objectives

Requirement	Objective	Benefit
Market & System Impact Analysis	• Understand the system impact of new technologies • Techno-economic analysis of costs/benefits of advances	Reduces the uncertainty and costs of technology adoption
Component Design & Development	• Design and prototype components with enhanced functionality • Support manufacturing ecosystem for cost, performance, adoption	Reduce the risk and cost of breakthrough componentry
Monitoring &Testing	• Develop embedded equipment sensors to improve design and operation • Testing and demonstration to show performance and value	Improve knowledge of component behavior and demonstrate viability
Applied Materials R&D	• Evaluate and develop new materials and devices that underpin advanced components	Foundational to improved performance and costs

On the Horizon

Solid State Substation

Two-way Power Advances

Transformer – Flexible Designs