UL Solutions

Enhancing electric grid reliability during the energy transition

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Agenda

- Introduction to UL Solutions
- Policy goals and key takeaways
- Challenges to grid reliability and solutions

UL Solutions, empowering trust through:

Technical advisory

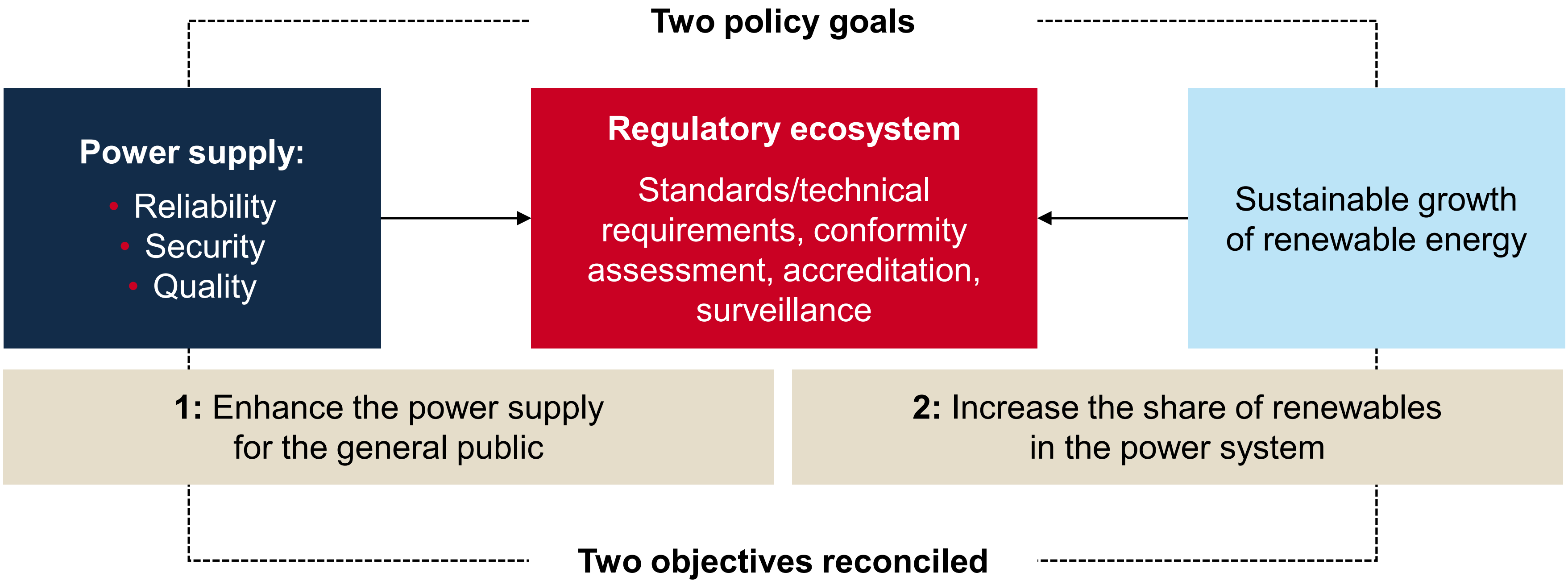
Testing, inspection and certification

Digital solutions

Key takeaways

- There is value in public–private partnerships toward delivering on regulatory objectives/mandates.
- Advanced system-oriented utility energy technical requirements and standards can play a major role in supporting grid reliability.
- International regulatory compatibility is extremely important in enabling long-term investments in grids that are safer and more reliable, sustainable and secure.
- It is critical to help regulatory frameworks align with international trade obligations and best practices.

Policy goals



Two policy goals

Power supply:

- Reliability
- Security
- Quality

Regulatory ecosystem

Standards/technical requirements, conformity assessment, accreditation, surveillance

Sustainable growth of renewable energy

1: Enhance the power supply for the general public

2: Increase the share of renewables in the power system

Two objectives reconciled

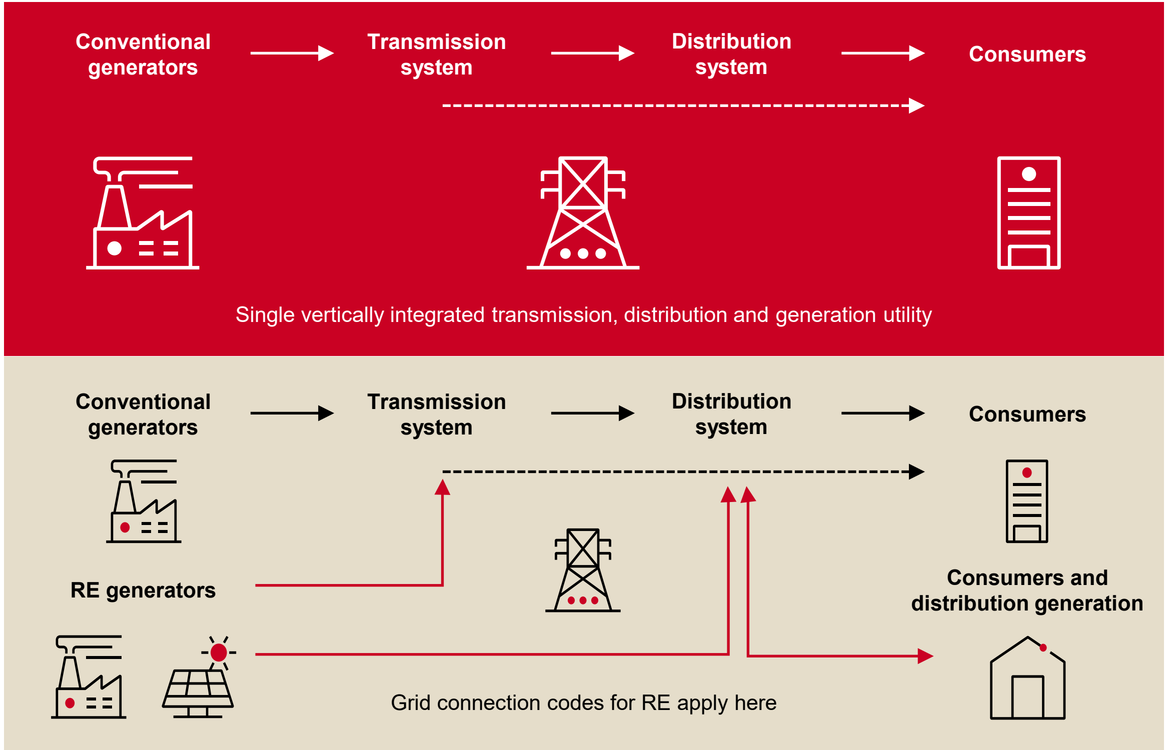
Modernization of grids

Traditional power system:

- Centralized generation
- Utility owns grid and generators
- Internal rules and requirements

Unbundled power system:

- Decentralized generation
- Separated ownership
- Need for grid code compliance and governance



Grid size vs. renewable energy (RE) integration

*Rate of change of frequency (**RoCoF**)

Limited frequency sensitive mode at over/underfrequency (LFSM-O/U**)

RE integration

	Small-scale system	Medium-scale system	Large-scale system
High	• Storage facility integration • Full frequency and voltage control capabilities • Grid-forming and black-start services from storage	• Grid-forming inverters for stability issues in regions without hydropower • Frequency control and active power control performance suitable for automatic generation control (AGC) integration required	• **Grid-forming services and black-start functionality to be provided by new assets connected to high-voltage levels** • **RoCoF* capability** • **Cybersecurity**
Stepping up	• LFSM-U** and active power control performance suitable for AGC integration • Requirements for enabling technologies, e.g., storage	• Fault ride through (FRT) capability and active power control requirement extends to new low-voltage connections • Requirements for enabling technologies, e.g., storage	• FRT capability and active power control controllability required for low-voltage connections • New requirements for larger facilities • Requirements for enabling technologies, e.g., storage
Starting	• Assets must withstand wider frequency and voltage range • Need for controllability and FRT capabilities (including small distributed energy resources (DER))	• Requirements must align with the state of the art, standards and rules of the RE industry • Power quality, protection, suitable frequency operating ranges and LFSM-O** must apply to all newly connected RE facilities and enabling technologies • For medium-voltage connections, requirements for power remote control and FRT are needed, but are not yet crucial for low-voltage connections	

Grid size

Addressing grid reliability

Challenge	Solution
Limitations of traditional utility energy requirements and standards, e.g., IEEE 1547-2003 and IEEE 1547.1-2005	Advanced inverter and system-oriented utility energy requirements and standards, e.g., UL 1741* SA and UL 1741 SB (IEEE 1547-2018 and IEEE 1547.1-2020)
High variation in grid requirements (global and domestic)	Increased regulatory compatibility in line with international obligations and best practices

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*UL 1741, the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

Limitations of traditional requirements and standards

Utility interconnection requirements

- Traditional utility interconnection requirements, e.g., IEEE 1547-2003 and IEEE 1547.1-2005, require distributed generation (DG) devices to disconnect when the grid is experiencing stability issues.
- This can increase grid instability and result in brownouts or blackouts.

Equipment safety standards evaluate:

- Functionality related to product-specific safety, including:
  - Electrical, fire and mechanical hazards
  - Verification of performance (environmental and electrical ratings)
- Hazards are evaluated and tested under normal and foreseeable abnormal conditions, including single-point component failures.

Grid reliability through a system-level approach

Example: UL 1741 — U.S. certification standard for grid-interconnected power inverters, converters and other generation equipment

Product types

- Utility-interactive inverters
- Grid-support inverters
- Stand-alone inverters
- Multi-mode inverters
- Interconnection systems equipment (ISE)
- AC modules
- Charge controllers
- Photovoltaic (PV) balance of systems (BOS) equipment
- Combiner boxes
- Ground fault detector interrupter (GFDI)
- PV rapid shutdown equipment and systems (PVRSE and PVRSS)
- Power control systems (PCS)

Source types and products covered

- PV
- Batteries and energy storage
- Fuel cells
- Micro-turbines
- Wind and hydro turbines
- Engine generator sets
- Electric vehicles (EVs)

Safety standard considerations

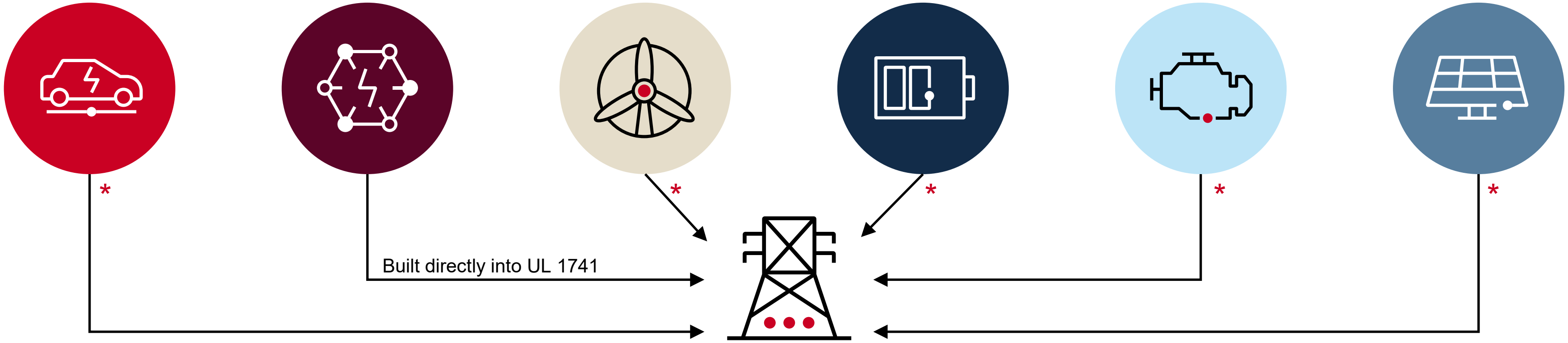
- Functionality
- Electrical hazards
- Fire hazards
- Mechanical hazards
- Functional safety
- Hardware and software
- Verification of electrical rating hazards under normal and foreseeable abnormal conditions

Performance considerations

- Grid code compliance
- PCS
- Regulation of V, A and W
- Communications
- Electrical and environmental extremes

Grid reliability through a system-level approach

A variety of DER safety standards refer to UL 1741 for utility-interactive requirements



EVPE
UL 9741
(offboard EVPE)

INVERTERS AND CONVERTERS FOR GRID INTERACTION AND SUPPORT
UL 9741

WIND CONVERTERS
UL 6142

ENERGY STORAGE SYSTEMS
UL 9540; UL 9540A
(battery fire safety)
UL 2262
(fuel cell modules)

ENGINE GENERATORS AND CONTROLS
UL 2200 (generators)
UL 6200 (controls)

MICROGRIDS AND SINGLE-SITE ENERGY SYSTEMS
UL 3001 (microgrids)

*QIKP for grid interconnection performance certification

See appendix for list of Standards

UTILITY INTERCONNECTION STANDARDS

UL 1741 SB – IEEE 1547 (2018), IEEE 1547.1 (2020)
UL 1741 SA – Configured with an SRD, e.g., Rule 21, 14H, etc.
UL 1741, Section 40 – IEEE 1547 and 1547.1 (earlier editions)

Note: QIKP for grid interconnection performance certification may or may not be linked to a base safety certification of a DER product type. QIKP certification will indicate linkage if applicable.

Existing variation in standards and technical requirements

Invertors expected to comply with:

- Product standards for safety, e.g., IEC 62109, UL 1741, etc.
- Code requirements for installation, e.g., National Electrical Code® (NEC)
- General utility interconnection requirements, e.g., IEEE 1547
- Special utility performance requirements, e.g., low-voltage ride-through, depending on the specific distributed resource and grid characteristics

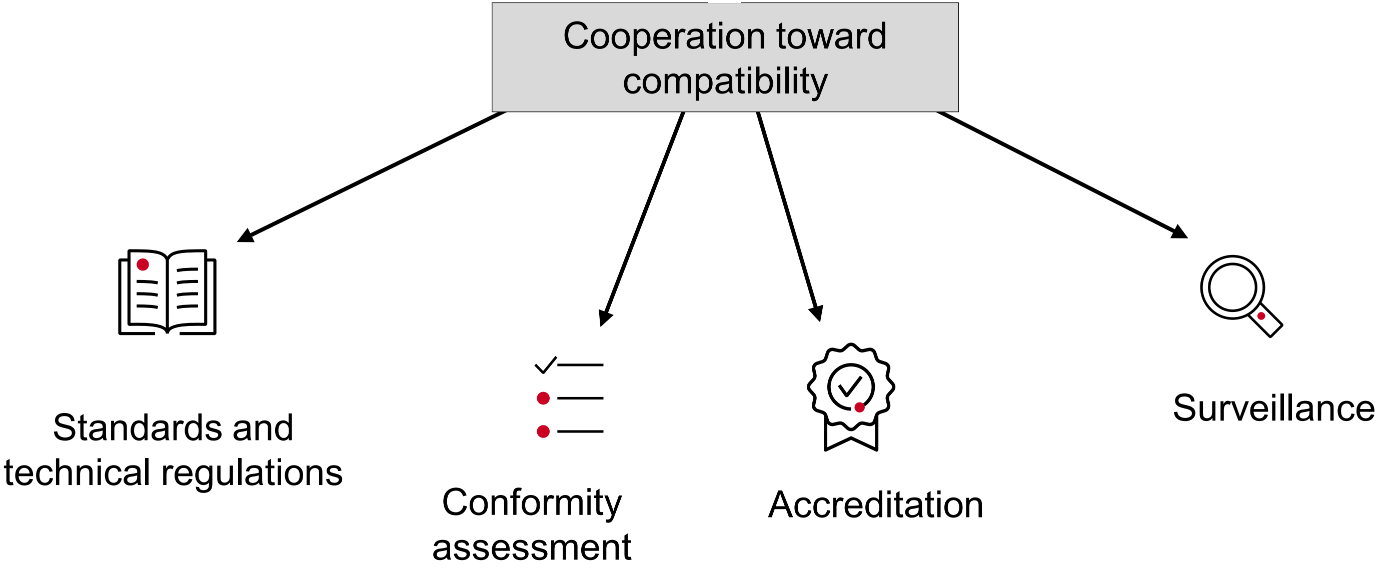
Differences among domestic and global requirements:

- Large numbers of domestic utilities, creating variety in interconnection requirements

- Patchwork of economy-level requirements hamper trade in key technologies

Regulatory compatibility

Regulatory cooperation: Preventing, reducing or eliminating unnecessary regulatory differences to facilitate trade and promote economic growth while maintaining or enhancing standards of public health and safety and environmental protection



Cooperation toward compatibility

Standards and technical regulations

Conformity assessment

Accreditation

Surveillance

Regulatory compatibility — recommendations

International standards:

- The use of international standards as the basis of technical regulations or conformity assessment is key to greater regulatory alignment and reducing barriers to trade.
- International standards as defined in the WTO TBT Committee Decision on International Standards[1]

Technical regulations:

Periodically review technical regulations and conformity assessment procedures to examine increasing alignment with relevant international standards, including review of any new developments in relevant international standards.

Conformity assessment:

- The choice of conformity assessment procedures in relation to a specific product covered by a technical regulation or standard should consider an **evaluation of the risks involved**, the need to adopt procedures to address those risks, relevant scientific and technical information, the incidence of noncompliant products, and possible alternative approaches for establishing that the technical regulation or standard has been met.
- Article 6.4 of the WTO TBT Agreement: “Members are encouraged to permit participation of conformity assessment bodies located in the territories of other members in their conformity assessment procedures under conditions no less favorable than those accorded to bodies located within their territory or the territory of any other country.”[2]

[1] WTO | Principles for the Development of International Standards, Guides and Recommendations

[2] WTO | Technical Barriers to Trade

Regulatory compatibility — recommendations

Depends on the conformity assessment system; for third-party systems:

Accreditation

- No discrimination against conformity assessment bodies whose accreditation body:
  - Operates in a territory with more than one accreditation body
  - Is a non-government body
  - Does not operate an office in the party’s territory
  - Is a for-profit entity
- Consider approving or recognizing conformity assessment bodies accredited by an accreditation body that is a signatory to a mutual or multilateral recognition arrangement. For example, the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF)

Surveillance

- Surveillance is an active step to help facilitate the continued validity of certification once a product is on the market.
- Third-party certification often includes surveillance in the conformity assessment process.
- Third-party systems like the U.S. build inspection/auditing into pre-market services so post-market surveillance is less costly.

Regulatory compatibility and grid reliability

Example: Batteries/energy storage systems

- Safety risks
- Evolving regulatory landscape
- Supply chain issues
- Accelerated product life cycles
- Limited local testing capabilities
- Slow testing laboratory turnaround time

Compatible regulatory frameworks foster innovation, promote consumer safety, and facilitate trade and investment in technologies that improve grid reliability.

Key takeaways

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Thank you

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