Celebrating 40 Years

Updating State Interconnection Rules for Advanced Inverter Functions and Improved Distribution System Modeling

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Outline of Presentation

1. How might new advanced inverter technical capabilities affect interconnection technical standards?
2. How might state rules and procedures be adjusted to reflect the new technical standards?
3. How are recent state rule updates addressing those factors?
4. What are possible future updates to state interconnection rules and procedures?

Research paper, co-authored by NREL Senior Engineer Michael Coddington, forthcoming fall 2017

Recent state actions on interconnection rules & procedures

- California (2016 & 2017)
- Colorado (in process)[1]
- Hawaii (2015 & 2016)
- Illinois (2017)
- Iowa (2016)
- Maryland (in process)[1]
- Massachusetts (2014)
- Minnesota (in process)
- Nevada (in process)[1]
- New Hampshire (2016)
- New York (2016 & 2017)
- North Carolina (in process)
- South Carolina (2016)

[1] Updates are under consideration now, especially for accommodating interconnected electricity storage

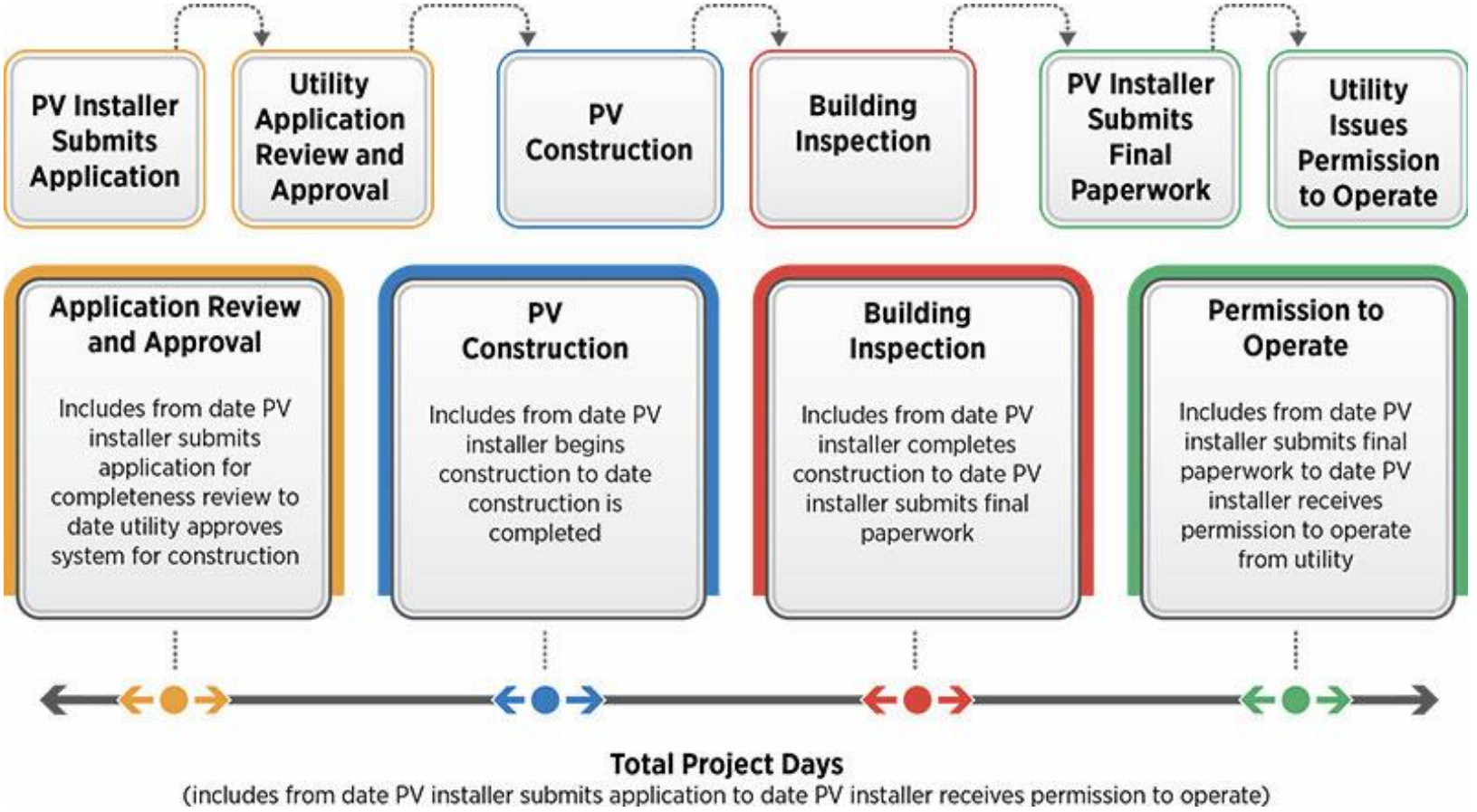
Topics under review (1)

- State name, year of initial rule, year of most recent update
- Citations to relevant laws, orders, and rules
- System size categories (often called “tiers” or “levels”), with details about:
  - application cost and fee structures by level;
  - timelines for each major step, for both utility and applicants by level; and,
  - provisions for study costs and payment options, by level
- Provisions for pre-application reports and meetings
- System “hosting capacity” maps by substation or feeder
- Provisions for electronic filing and on-line tracking
- Applicable codes and standards (e.g., IEEE, UL, etc.)

Topics under review (2)

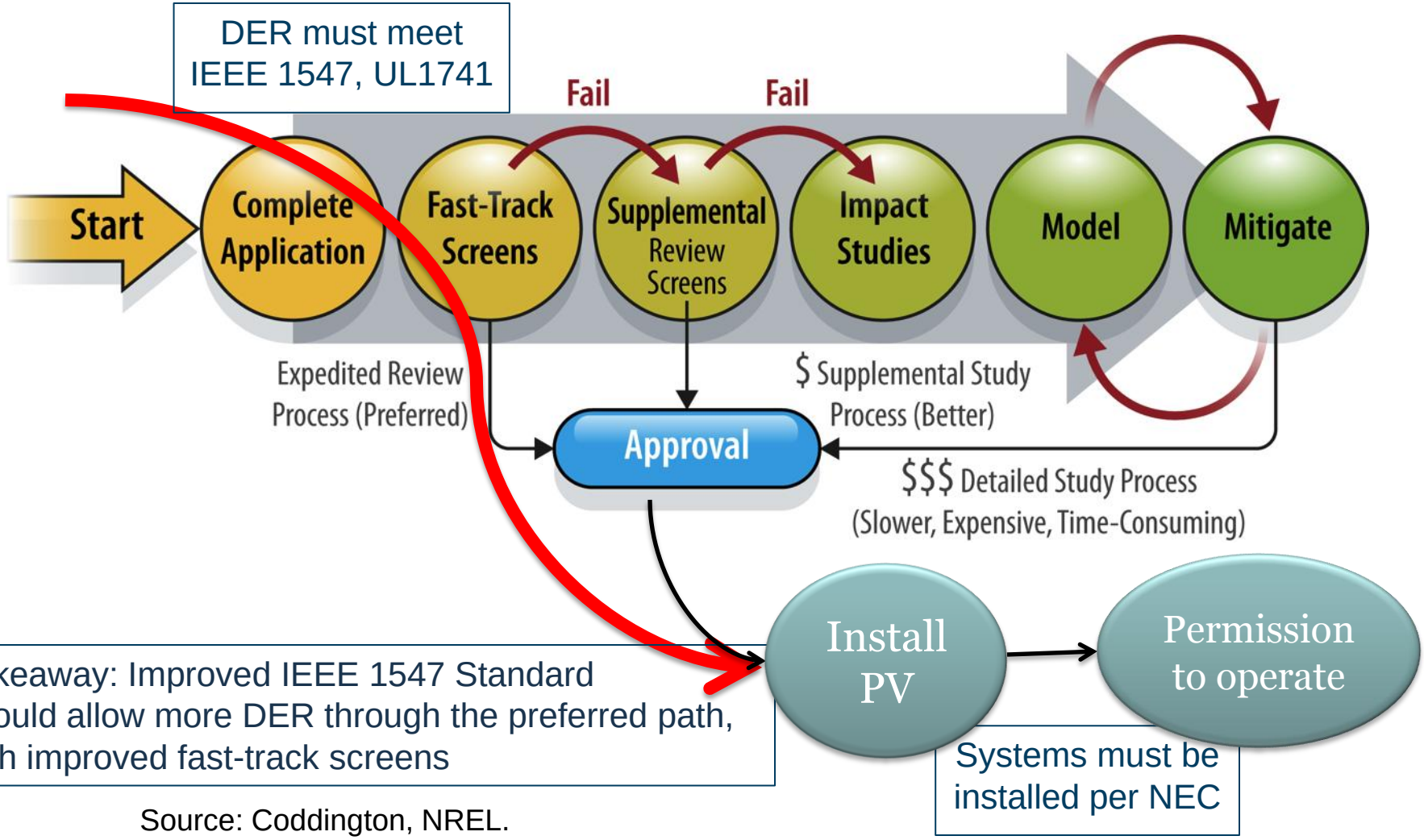
- Insurance requirements, if any
- Equipment certification
- Dispute resolution procedures
- Any special provisions for:
  - "group studies" where more than one interconnection is planned for a particular segment of the grid;
  - energy storage;
  - microgrids; and,
  - advanced (also sometimes called "smart") inverters
- Any additional factors that may be helpful to other jurisdictions considering changes to interconnection standards, rules, and procedures

Typical interconnection process



Source: Barnes, Barnes, et al., 2016, *Comparing Utility Interconnection Timelines for Small-Scale Solar PV, Second Edition.* EQ Research. http://eq-research.com/wp-content/uploads/2016/10/EQ-Interconnection-Timelines-2016.pdf

Typical utility review process



Takeaway: Improved IEEE 1547 Standard should allow more DER through the preferred path, with improved fast-track screens

Source: Coddington, NREL.

Is there a problem? (1)

"Federal and state regulators are faced with the challenge of keeping interconnection procedures updated against a backdrop of evolving technology, new codes and standards, and considerably transformed market conditions."

Source: Fox, Stanfield, Coddington, et al., 2012, *Updating Small Generator Interconnection Procedures for New Market Conditions,* NREL/TP-5500-56790. http://www.nrel.gov/docs/fy13osti/56790.pdf

New inverter technical capabilities

- The goal is for inverters operating as "integrated grid assets," ensuring interconnected DG will always act as "*good grid citizens*"
- Advanced (a.k.a. "Smart") inverters can "respond automatically and autonomously *and* respond to direct communications signals from grid operators" to:
  - physically connect to or disconnect from the utility grid;
  - adjust generation level, power factor, reactive power;
  - set parameters for frequency and voltage ride-through; and,
  - maintain and communicate an accurate events log and operating history

Source: Reiter, E., K. Ardani, and R. Margolis, 2015, Industry Perspectives on Advanced Inverters, NREL/TP-7A40-65063, http://www.nrel.gov/docs/fy15osti/65063.pdf

New utility capabilities

- Fast, reliable and valid distribution system modeling, capable of analyzing all major types of DER resources
- Readily accessible maps showing substation and feeder "hosting capacity," to help focus attention on difficult, good, better, and best locations for installing DG
- Toolkits of more and better mitigation techniques are enabling more DG on existing circuits, with fewer and less expensive upgrades required

IEEE 1547 Standards Revisions are Coming

- Entire standard is open for revisions
- Already-identified topics include:
  - Voltage ride-through & frequency ride-through capabilities and variable settings for grid support, including Volt/VAR, Volt/Watt, frequency/Watt, etc.
  - Revised power quality settings and requirements
  - Provisions for intentional and unintentional islanding
  - Secondary network interconnection guidelines
  - Energy storage systems
  - Grid support functions and interoperability

Additional IEEE 2030 Series of Smart Grid Interoperability Standards

- **P2030.1**—guide for electric transportation systems
- **2030.2-2015 (approved)**—guide for interoperability of electric storage systems
- **2030.3-2016 (approved)**—applications for electric storage, including testing procedures for safety and reliability
- **P2030.4**—guide for electric power systems control and automation installations
- **2030.5-2013 (approved)**—communications between the smart grid and consumers
- **2030.6-2016 (approved)**—guide for monitoring the effects and evaluating benefits of demand-response programs
- **P2030.7**—specifications for microgrid controllers
- **P2030.8**—standards for testing microgrid controllers

Many states' updates provide:

- Uniform state rules & procedures, application forms and operating agreements, for all utilities
- Online & electronic interconnection applications
- Overall streamlined, transparent processes with more open communication between utility & developers
- Simple, online project and application status tracking
- Rapid grid-impact studies approaches, using sophisticated distribution system software modeling
- Supplemental screening options, optionally employing multiple low-cost mitigation strategies, using a "safety valve" approach for simpler problems, thus avoiding more expensive impact studies
- "Solar-ready communities" actions to reduce soft-costs

Preliminary observations

Possible adjustments to state rules

- Implement greater transparency and state-wide consistency
- Be ready to incorporate autonomous and controllable advanced (smart) inverter functions for grid support
- Focus on how utilities plan and model their distribution systems, to support increasing DG capacity
- Require substation/feeder hosting capacity reports and maps
- Tighten time frames for utility procedures, to accommodate improved modeling capabilities and logical sequences of least expensive mitigation strategies.

Supplementary regulatory approaches

- Revise retail and wholesale rates to reward any and all DER capabilities that produce and deliver system benefits, including multiple revenue streams if necessary
- Encouraging utilities to fully integrate distributed resources into their planning processes, including electric/water/stormwater/wastewater utilities.