

Certification of Distributed Wind Technology to Electrical Standards

Joseph Spossey – RE Innovations

NREL/DOE CIP Informational Workshop

Tuesday November 28, 2023



Who We Are

RE Innovations is a team of wind turbine design, testing, certification and product development experts providing independent evaluation and analysis of wind turbine systems and components. On the path to certification, REI helps OEMs plan and prepare by understanding the design, test, and certification requirements, time and associated costs. Helping to better understand and interpret the standard requirements to determine any design gaps or flaws in the design documentation. REI also independently evaluates and tests wind turbines for certification compliance.

1 Simple Goal

A CLEAR PATH TO CERTIFICATION

My Background

10 years at Intertek, 2009 – 2019

17 years wind turbine related experience

Accreditation, International Standardization, ACP and IEC Type Testing, Certification and Advisory Services.

MT2 IEC 61400-2 Secretary

MT12 IEC 61400-12-1 Annex H topic leader

ARESCA Member

ACP Wind Technical Standards Committee

UL STP 6142

Customer and 3rd party wind turbine type testing expert



TOPICS & OBJECTIVES



What's required for DW Electrical Safety and Why?



Understand US Electrical Conformity for DW Turbines



Discuss UL 6141 vs. UL 6142 = Entry vs. Non-entry



Identify common turbine components and requirements



Prepare for CIP topic areas covering Electrical Conformity



SINCE WE LAST MET...

Last CIP Workshop – December 2021 – Dr. Rob Wills, Intergrid

- Presentations / Workshop posted on NREL site
- Similar info, updated, some new insights
- NEC (new), IEEE 1547 (similar), UL 6142 (same)

Updates to National Electrical Code, NFPA 70®

- Current edition 2023
- No major changes for wind turbines, Article 694

Updates to UL 6141 (entry) and UL 6142 (non-entry)

- UL 6141 updated October 2022
- UL 6142 Ongoing under STP 6142
- Discuss both today

Updates to IEEE 1547 adoption (always updating)

Updates to NEC adoption (always updating)

Clarification of UL 1741 SA/SB and interactive ‘options’ or types

We’ll discuss these things, and more!



Sonsight 3.5kW

COMPLIANCE DRIVERS



Permitting / Zoning

- Building Permits, Electrical Permits, Special / Conditional Use
- Noise Ordinances, Environmental Assessments

Baseline Quality and Risk Mitigation

Eligibility for Tax Rebates, Incentives, Others

- ITC, PTC Tax Credits
- State Adopted Incentive / Rebate Programs
- USDA REAP

Local Authorities / Municipalities

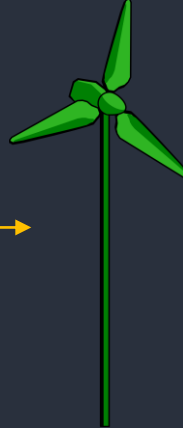
- Code Adoption and Enforcement
- See US Maps, IEEE 1547 Adoption

Export Markets

- Certification Requirements
- Local Requirements

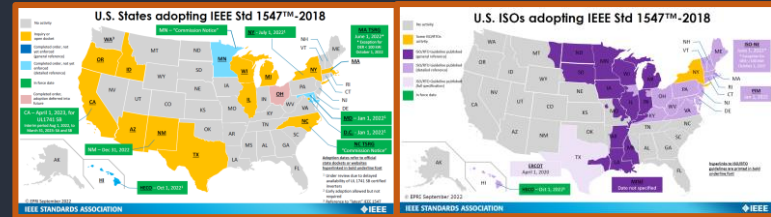
DW TURBINE ELECTRICAL CONFORMITY SUMMARY

The system is installed per the National Electrical Code;
Verified by local Authorities Having Jurisdiction (AHJ)



The complete DW Turbine system must be listed to:

- UL 6142: *Standard for Safety for Small Wind Turbine Systems*; or,
- UL 6141: *Wind Turbines Permitting Entry of Personnel*



The grid connected device must be listed to:

- IEEE 1547: *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces, including 1547.1 testing*; and,
- UL 1741: *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources*

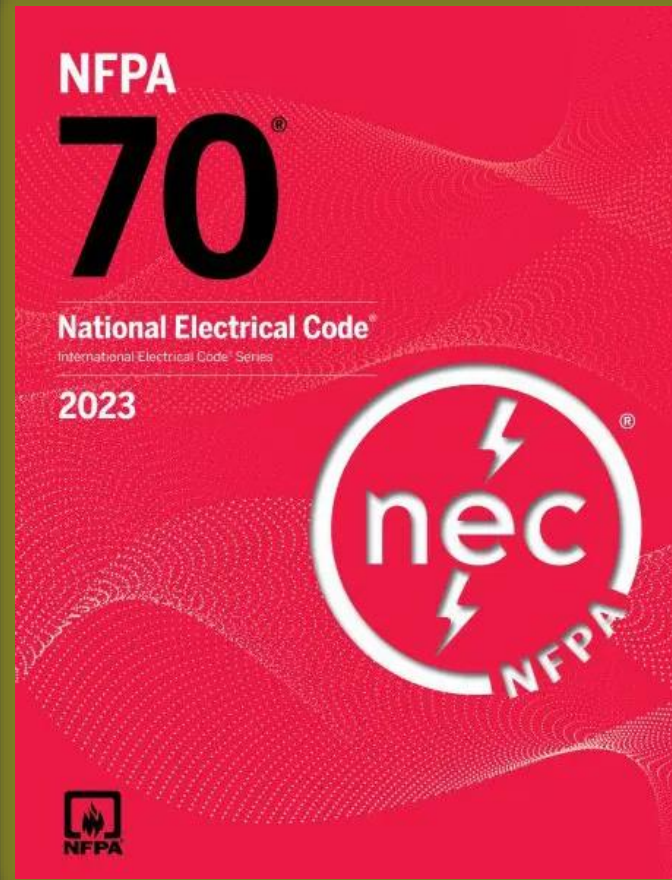
In some jurisdictions, the inverter must also meet new communications requirements in IEEE 2030.5-2018

Article **694** of NEC applies to Wind Electric Systems. Other articles may apply including:

- **705** Interconnected Electric Power Production
- **706** Energy Storage Systems
- **710** Stand Alone Systems
- **712** Direct Current Microgrids



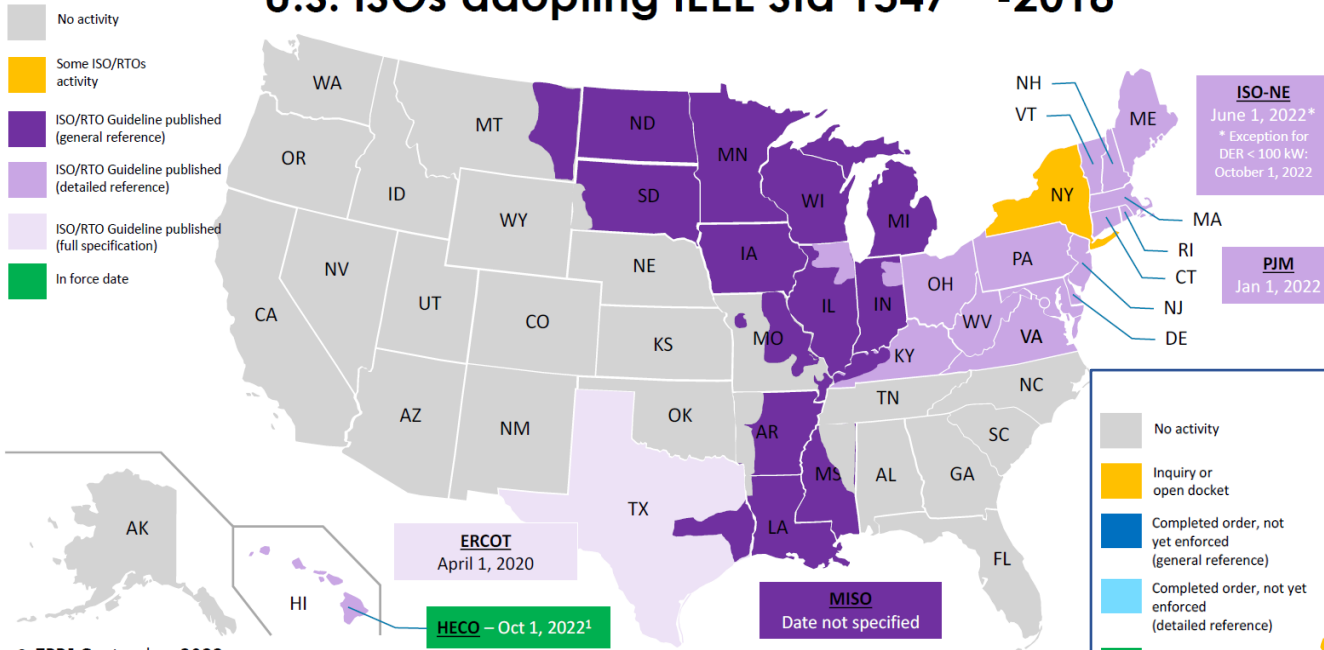
NEC, NFPA 70[®]



- 2023 latest edition
- Applies to wide range of electrical products; for DW Turbines:
 - Chapter 6 Special Equipment: 694 Wind Electric Systems
 - Chapter 7 Special Conditions: 705 Interconnected Electric Power Production
 - Others as applicable:
 - 706 Energy Storage, 710 Stand alone systems, 712 DC Microgrids
- General Sections (Ch 1 – 4), Special Sections (Ch 5 – 8)
 - Special Equipment Ch 6, Special Conditions Ch 7
 - Special Sections override General Sections
- Field labeling still allowed
 - Generally same requirements discussed today
 - Applies only to the single turbine installation (single label)
- Disconnects, protection ratings, labelling, wiring practices, and grounding, etc.
- Many of these things are prescribed by product standards

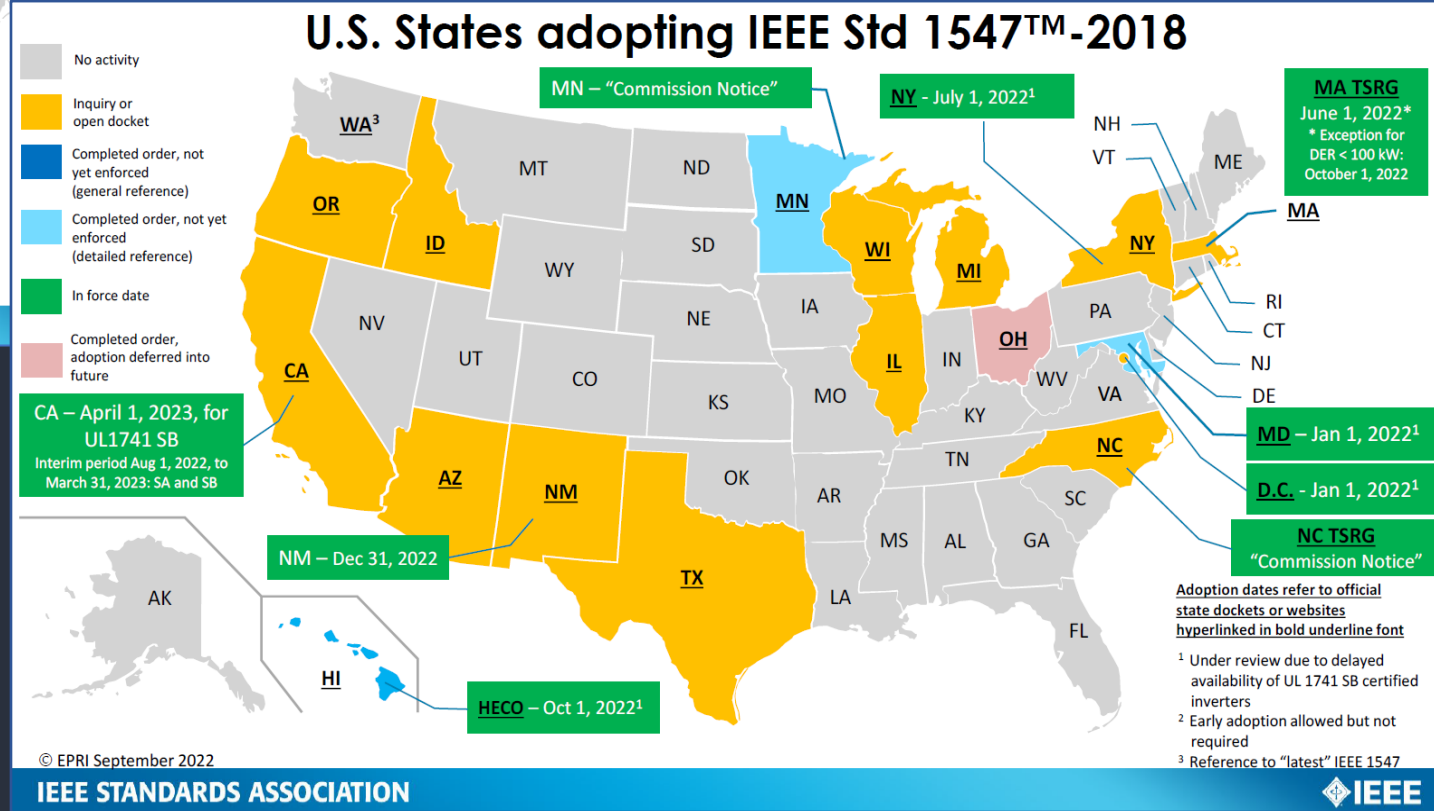
INTERCONNECTION CONFORMITY

U.S. ISOs adopting IEEE Std 1547™-2018



- IEEE Std 1547™-2018 Adoption; EPRI Presentation:
- <https://sagroups.ieee.org/scc21/standards/1547rev/>
- Use these maps to determine UL 1741 SA / SB compliance for grid interconnection device, including IEEE 1547 and 1547.1. Refer to UL 6142 cl 9.
- UL 61800-5-1 allowed for safety of device; with 1547

U.S. States adopting IEEE Std 1547™-2018



IEEE STANDARDS ASSOCIATION

IEEE Std 1547™-2018

Status of Adoption across the U.S.
September 2022

IEEE Standards Coordinating Committee 21 (SCC21)
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

<https://sagroups.ieee.org/scc21/standards/1547rev/>

Courtesy of Electric Power Research Institute (EPRI)
<https://www.epri.com/#/pages/product/000000003002012048/>

IEEE STANDARDS ASSOCIATION

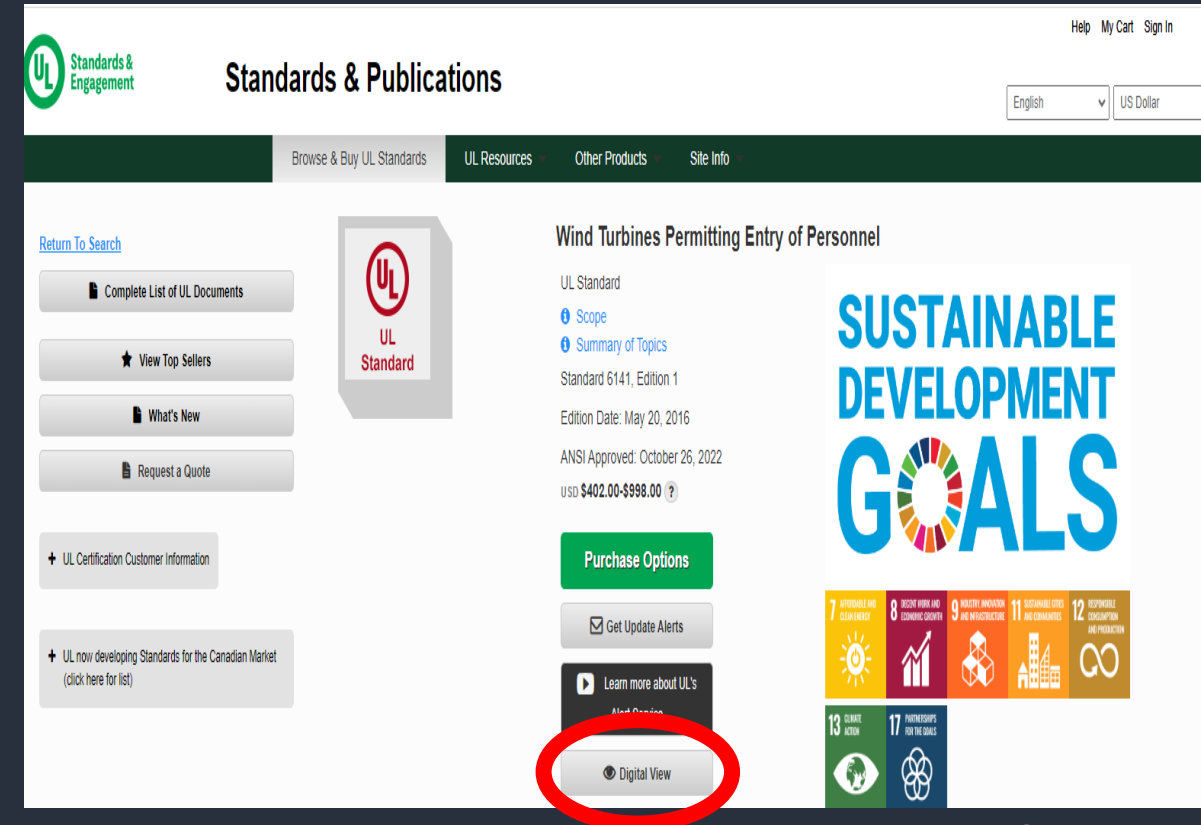
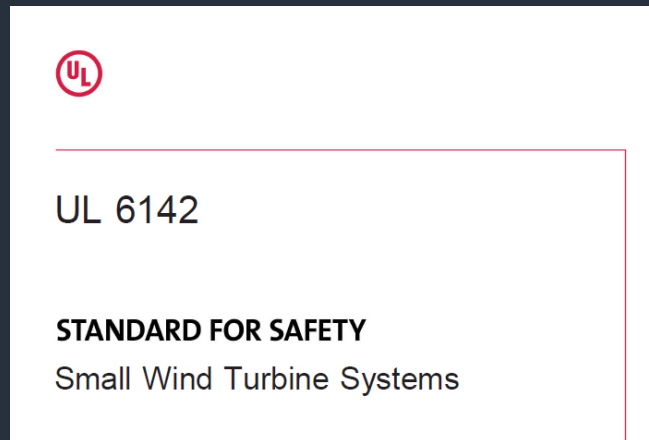


DW TURBINES UL 6141 / UL 6142 CONFORMITY

- OSHA Accredited Nationally Recognized Testing Laboratory; <https://www.osha.gov/nationally-recognized-testing-laboratory-program/current-list-of-nrtls>
- www.shopulstandards.com sign up for a free account, and be able to digitally view many UL standards referenced today for FREE

- UL 6141 / UL 6142 Safety Certification Process (general):

- Documentation Desktop Review / Critical Components Review
- Constructional Evaluation
- Type Testing
- Final Evaluation / Reporting
- Factory Inspection
- Labeling and Certification
- Surveillance / Maintenance



ELECTRICAL CERTIFICATION TYPES AND TERMS

Classification Listing of a Wind Turbine System

- “Listing” = public listing of the Certificate or other Certification documents
- 3rd party accredited Nationally Recognized Testing Laboratories (NRTL)
 - OSHA’s NRTL Program, Scopes identify allowable standards
- “Classification Listing” typically used for a grouping of components and subassemblies that on their own do not make up a complete system usable to the consumer
- UL 6141 or UL 6142 applicable listing standards

Recognition Listing of a Component or Subassembly

- Listing – full compliance with the product standard (e.g., inverter UL 1741)
- Recognition Listing – partial compliance or incomplete on its own, requires other system components for compliance with the product standard (e.g., generators UL 1004 and controllers UL 1741)
- Limited Evaluations in rarer cases where component is evaluated for use only in system
- Unlisted equipment, additional surveillance requirements

Field Label of single turbine system installation

- In lieu of the above listing, classification, and recognition
- NEC and UL 6141 or UL 6142 typically referenced by AHJ / Inspector
- Same component and subassembly requirements
- Same interconnection requirements
- Single label once approved
- Custom, one-off approach, some exceptions may be allowed by AHJ with additional protections employed

DW TURBINE SYSTEMS AND COMPONENTS

UL 6142 Small Wind Turbine Systems

- Ed.1 Rev 2020
- STP 6142 active, updates pending similar to UL 6141
- “User or service person cannot or is not intended to enter the turbine to operate it or perform maintenance”
- WT rated 1500 VAC or less
- Installed per NEC NFPA 70
- Safety Evaluation of Components / Subassemblies
 - Wiring, splices, cable loops, bus bars, terminations, etc.
 - Switchgear, transformers, slip rings, panelboards
 - Emergency Stops and other disconnecting devices
 - Converter / Inverter / Controller – UL 1741
 - Alternators, generators, and motors – UL 1004
 - Energy Storage Units
 - *Motor Drives – to be added*
- General Safety Evaluation
 - Spacings, 601 – 750V rated equipment, Grounding
- **Safety Related Control Systems**
 - 61400-2 Design, Safety and Function Testing, Risk Assessment / FMEA
- Utility Grid Interaction
- Ratings, markings, manuals

UL 6141 Wind Turbines Permitting Entry of Personnel

- Ed.1 Rev 2022
- Updated to include International wiring methods, standards, etc.
- “These requirements cover large wind turbine systems that are equipped with electrical subassemblies and permit the entry of personnel”
- Circuits operating 1000 VAC / 1500 VDC or more
- Installed per NFPA 70, NESC, and NFPA 79
- Safety Evaluation of Components / Subassemblies
 - Wiring, splices, cable loops, bus bars, terminations, etc.
 - Switchgear, transformers, slip rings, panelboards
 - Emergency Stops and other disconnecting devices
 - Converter / Inverter / Controller – UL 1741
 - Alternators, generators, and motors – UL 1004
 - Energy Storage Units
 - Motor Drives – UL 61800-5
 - MV, HV, elevators, others
- General Safety Evaluation
 - Spacings, 601 – 1000V rated equipment, Grounding
- **Safety Related Control Systems**
 - 61400-1 Design, Safety and Function Testing, Risk Assessment / FMEA
- ~~Utility Grid Interaction~~ Service Personnel Safety
- Ratings, markings, manuals

DW TURBINE SYSTEMS AND COMPONENTS (cont.)

Turbine Component or Subassembly	Applicable Standards
Rotating Hub	UL 6141 / UL 6142, IEC 61400-1, IEC 61400-2
Wind Turbine Generators	UL 1004-1, UL 1004-4
Wind Turbine Motors	UL 1004 series, IEC 60034-1, and others
Control System and Equipment	UL 6141 / UL 61421, UL 1741
Motor Drives	UL 61800-5-1
Adjustable Speed Power Drives	UL 61800-5-1 and UL 1741 if conversion
Converters	UL 1741
Inverters	UL 1741, IEEE 1547, IEEE 1547.1
Gearboxes	UL 508
Diversion Loads	UL 499, UL 508, others
Emergency Stop	UL 6141 / UL 6142, IEC 61400-1, IEC 61400-2
Disconnect Devices	UL 6141, NFPA 79
Lightning Protection Systems	NFPA 780, IEC 61400-24, UL 1449 (devices)
Brakes, Couplings and Locking Devices	UL 6141 / UL 6142
Cooling and Heating Systems	UL 6141 / UL 6142
Controllers and Safety System Components	UL 6141 / UL 6142, IEC 61400-1 / -2, UL 61010-1

DW TURBINE ELECTRICAL COMPLIANCE CONSIDERATIONS

Inverters, interactive type (3 options)

- **1 Utility Interactive** – traditional method, 2003 version of IEEE is STILL OK
 - “Old School“
 - Anti-islanding; get out of the way!
- **2 Grid Support Utility Interactive** – IEEE 1547-2018 and IEEE 1547.1-2020
 - “New School”
 - Ride through; support the grid! (SA, or SB + IEEE 2018)
- **3 Special Purpose Utility Interactive**
 - Specific, OEM or Utility defined
 - UL verified compliance
- Is a PV inverter OK?
 - Yes, but
 - Add control equipment / rectifier to smooth power curve
 - Appropriately classified interactive type, listed accordingly, and used within ratings

Alternators, Generators, and non-inverter machines

- PMG may be simple, but UL 1004 is not unless you are prepared!
 - Some off the shelf certified options, but may not match your specifications
 - Custom or designed and built for the given turbine – leads to compliance gaps
- Insulation system UL 1446 certified → largest compliance issue
 - System of components, not piecing together individually listed items
 - Comes down to the temperature test → Windings not exceeding 100C
 - Allowable exception for Class A insulation system, and reduced requirements
 - If above 100C, MUST!!!!!! Be UL 1446 certified with OEM approval letter
- Non-inverter machines – same requirements
 - Utility interactive protective device / relay
 - UL 1741 and IEEE compliance and protections

SRCS and Safety and Function Testing

- Safety Related Control Systems, Cl 8 UL 6141 / UL 6142
- If you build it, we will test it!
- Risk assessment/FMEA + IEC/ACP protection system design + SRCS TESTING!
- All setpoints, features, including primary / secondary control and protection
- Can approach 50 tests overall; coordination of testing critical

Custom built electronics, drives, and more!

- UL 6142 and 6141 require general compliance with UL 1741 or NFPA 79
- Control equipment must comply with UL 1741 applicable parts
- Variable Frequency Drives or other electrical drives / motor drives – UL 61800-5 (w/UL 1741 if conversion)

Certification Planning

- Coordination of connected elements of the certification process
- Environmental testing of multiple components or systems simultaneously
- SRCS and S&F detailed test planning
- Detailed design, test, and certification requirements
 - Component and subassembly requirements
 - System and interconnection requirements
- Documentation preparation
 - BOMs, specifications, schematics, drawings, manuals and labels
 - Insulation system components, ratings, and certifications
- CE Marking is not accepted in the US, but technical file may be useful

POTENTIAL ELECTRICAL CIP TOPIC AREAS

- Prototype Design Development
 - Early stage system design
 - Component design / specification, supplier qualification
- Component Innovation & System Optimization
 - Custom component / subassembly design and testing
 - Control system optimization
 - Electrical system optimization
- Small Wind Certification and/or Listing
 - UL 6142 system classification listings
 - Component / subassembly certifications
- Type Certification and Listing - Same as above, but UL 6141
- Manufacturing Process Innovation
 - Electrical manufacturing for large scale production
- ~~Product Commercialization and Market Development - Not typically electrical in scope~~
- ~~Prototype Manufacture & Installation - Not typically electrical in scope~~
- ~~Prototype Installation & Testing~~
 - Not typically electrical in scope, but...
 - Electrical system testing for commissioning / interconnection?

[These are some my ideas, let's check with Ian and Brent...]

Competitiveness Improvement Project

Since 2012, NREL will have awarded:

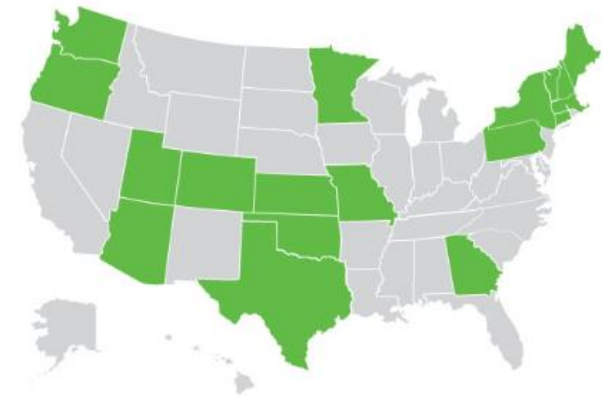
 **64**
subcontracts

 **\$15.4M**
total U.S.
Department of
Energy funding

 **26**
companies

 **\$7.9M**
additional
private-sector
investment

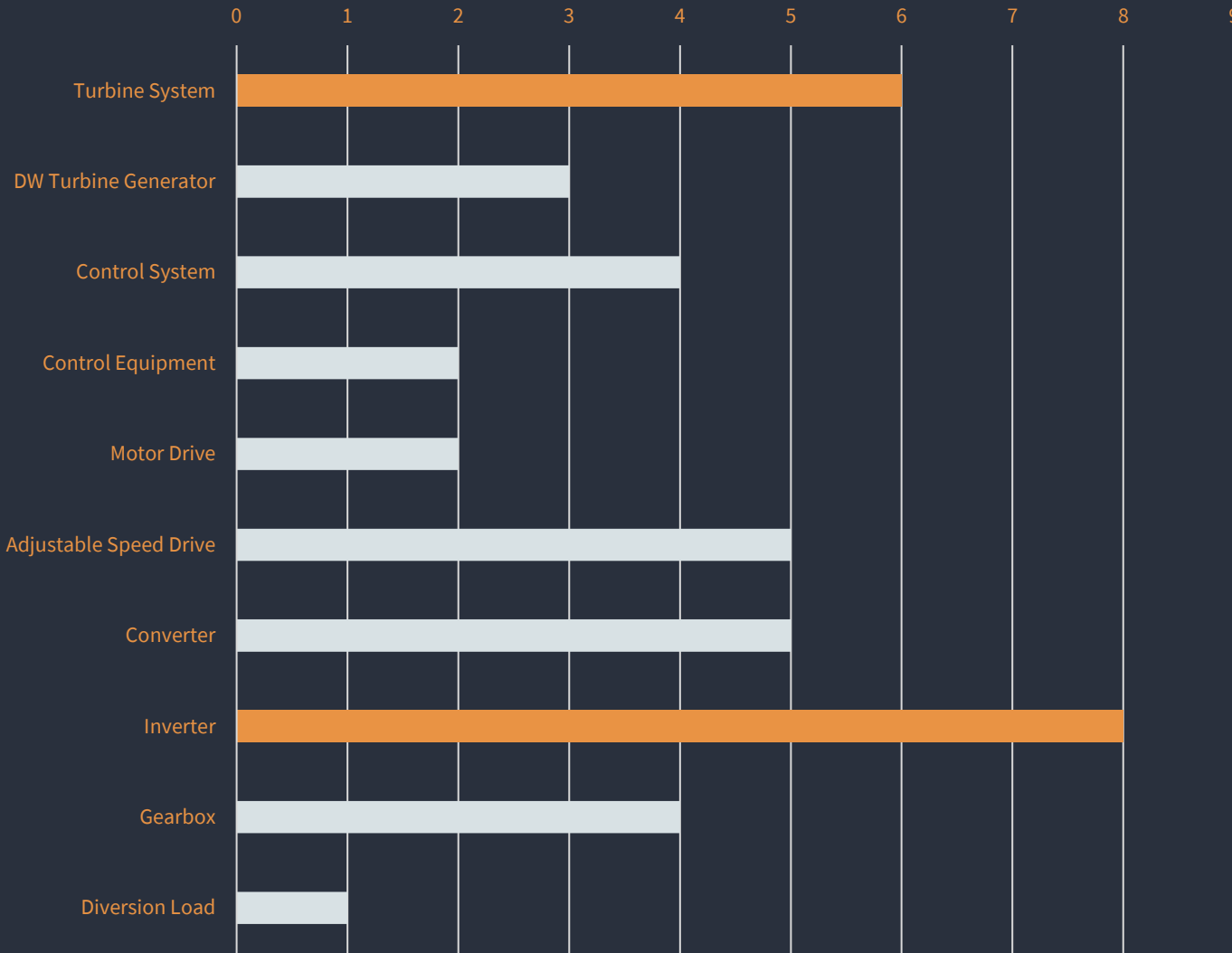
The Competitiveness Improvement Project supports companies from across the nation.



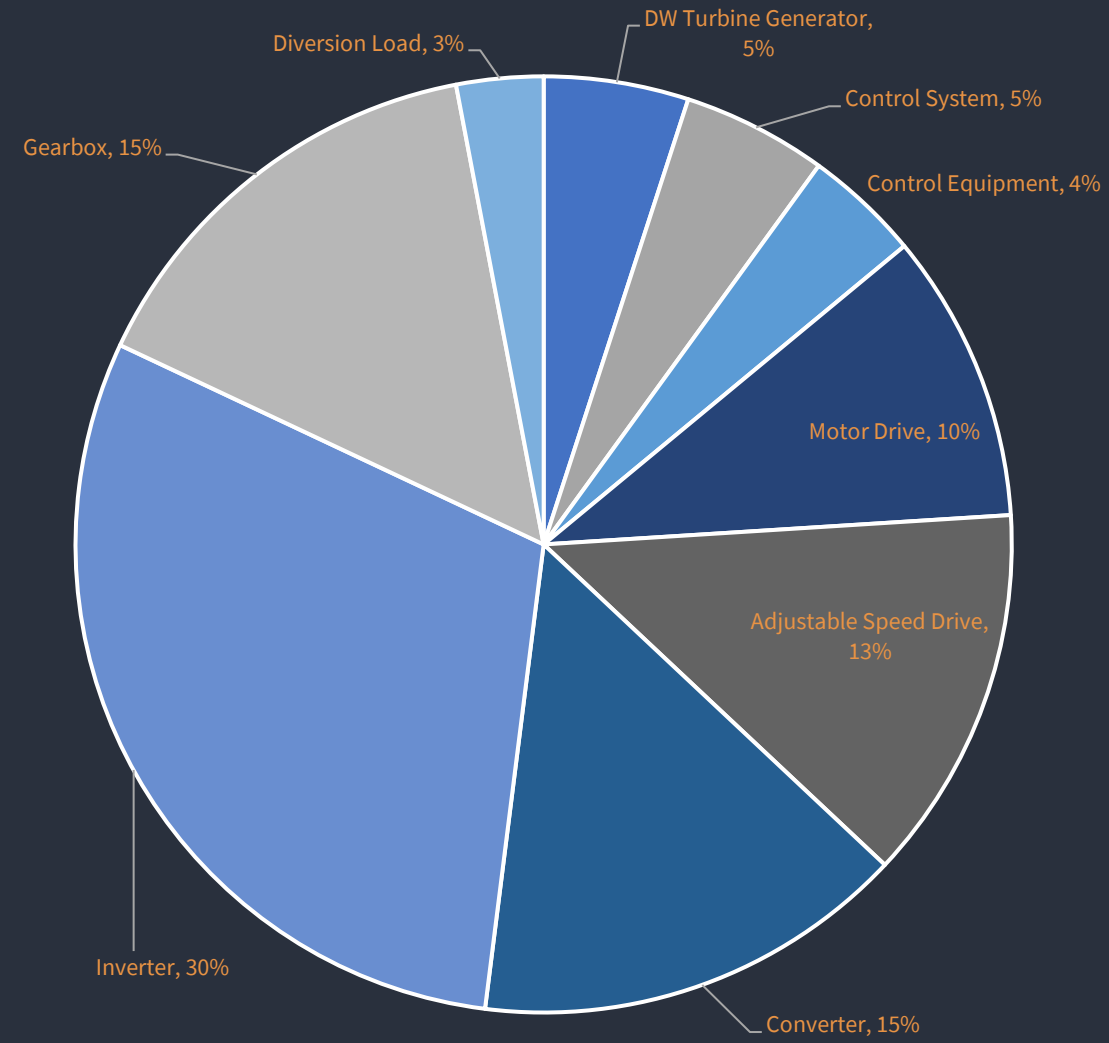
Why CIP? Let's see..

DW TURBINE CERTIFICATION TIME & COST – UL 6142 / UL 6141






System and Component Electrical Certification Time Estimates



System and Component Electrical Certification Cost Scale



DID WE COVER EVERYTHING?

- ✘  What's required for DW Electrical Safety and Why?
- ✘  Understand US Electrical Conformity for DW Turbines
- ✘  Discuss UL 6141 vs. UL 6142 = Entry vs. Non-entry
- ✘  Identify common turbine components and requirements
- ✘  Prepare for CIP topic areas covering Electrical Conformity



THANK YOU FOR YOUR TIME!

QUESTIONS?

Joseph M Spossey

CEO/Owner

Wind Engineering & Certification Consultant

RE Innovations LLC

+1 678-733-5131

joseph.spossey@reinnovationsllc.com

www.reinnovationsllc.com



 **INNOVATIONS**