



Photovoltaic and DER System Interconnection Concepts

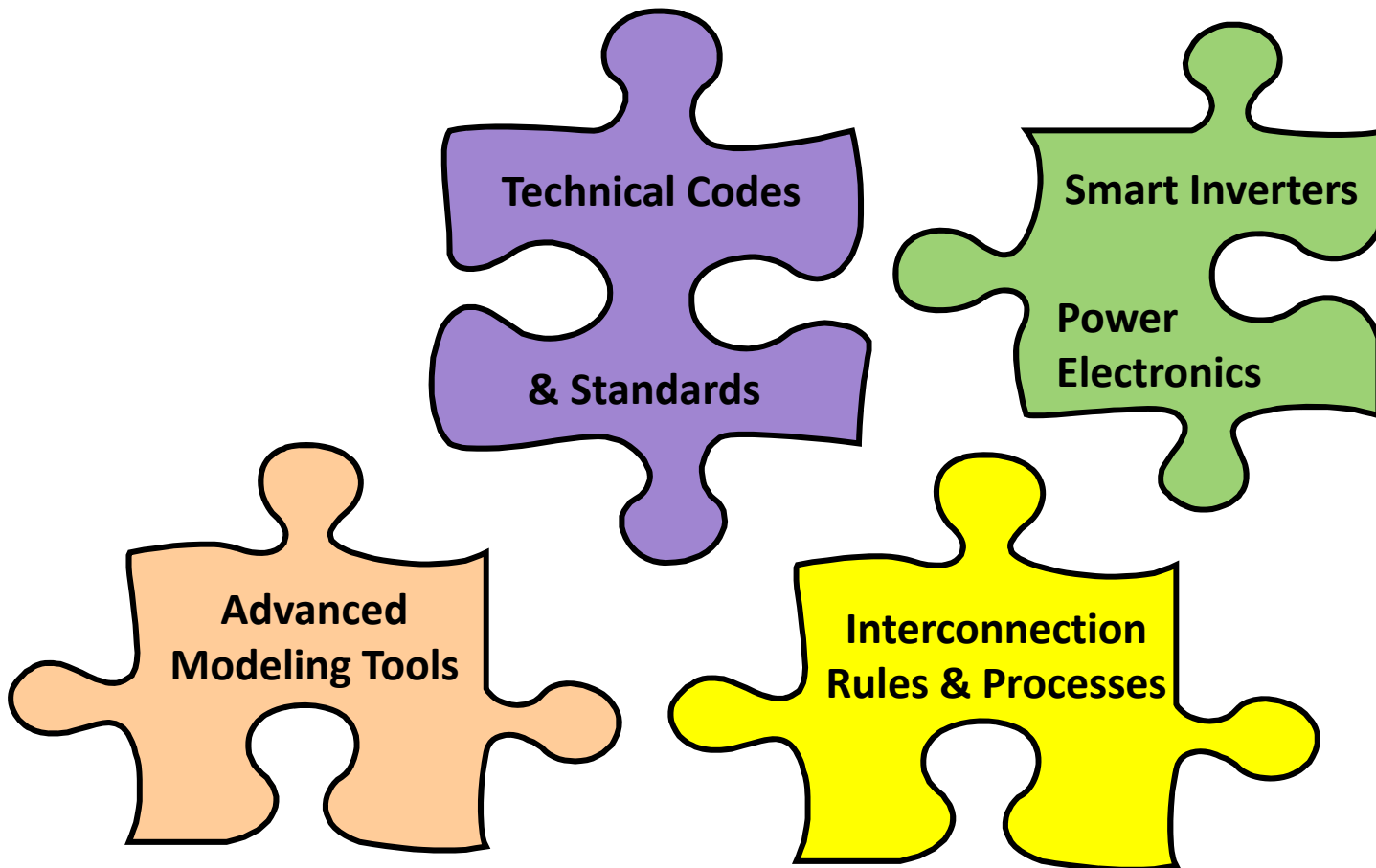
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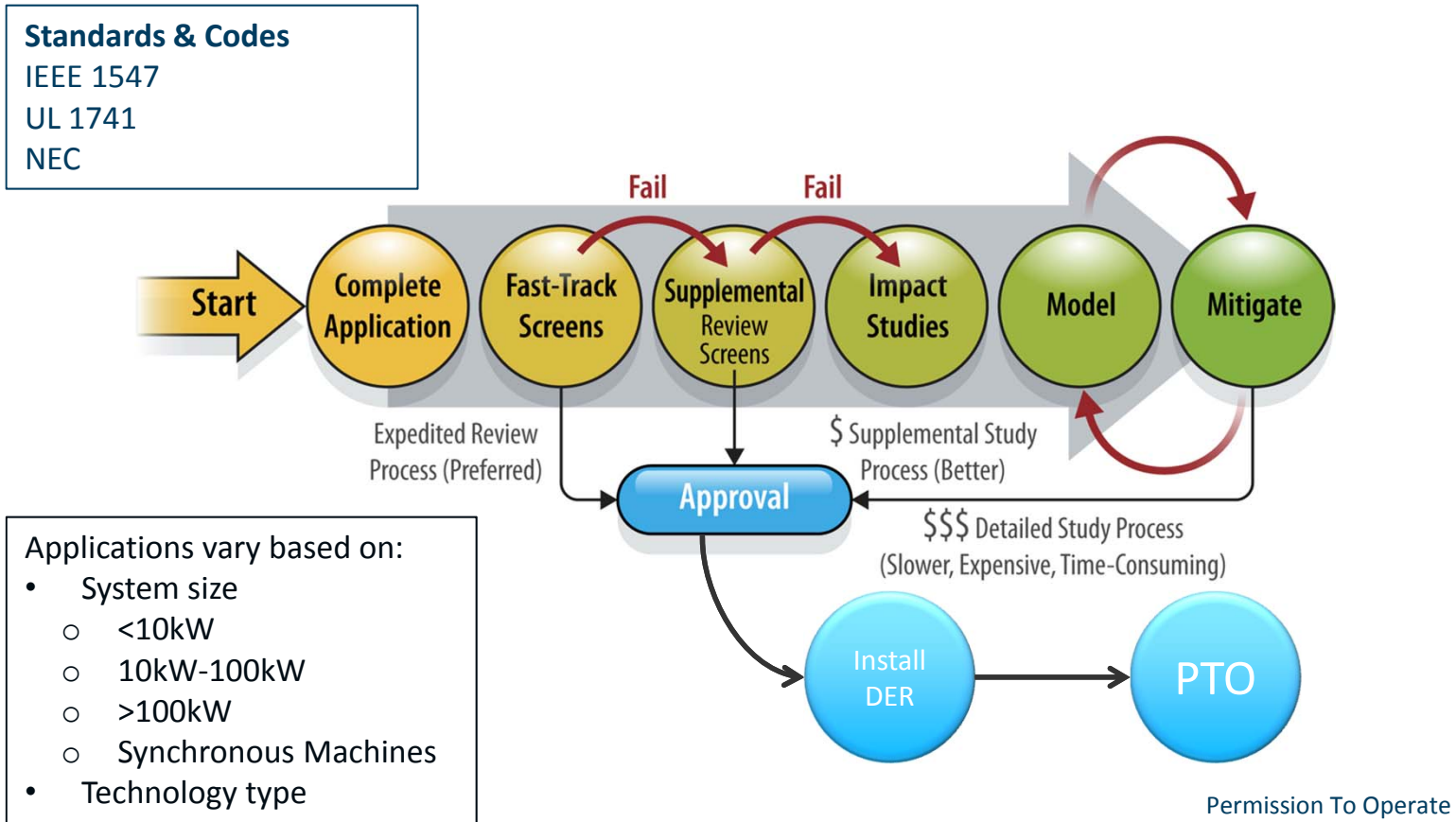
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DER Interconnection Puzzle Pieces



Each Puzzle Piece is Very Important!

Normalized Utility Interconnection Process



Technical Screens – Not All are Helpful & Useful

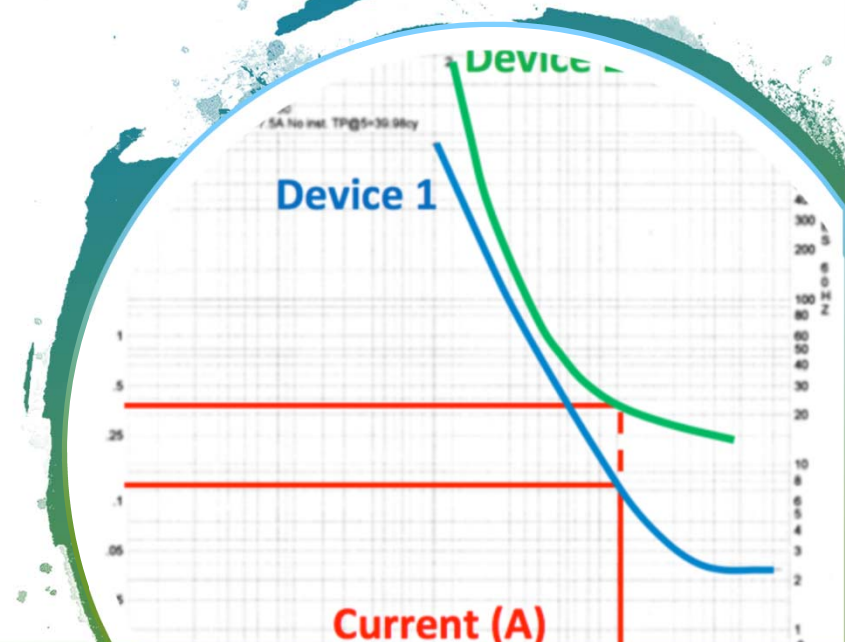
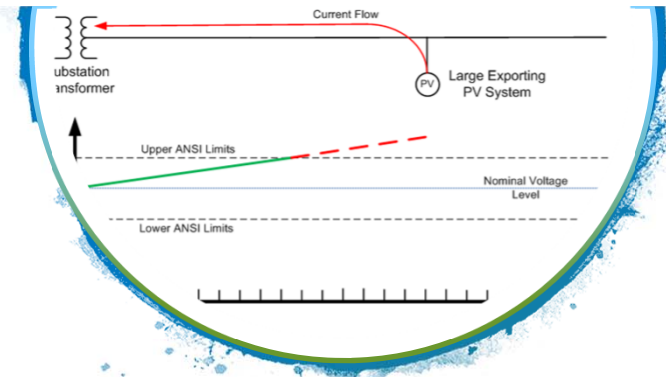


1. Is the application subject to the utility tariff?
2. Aggregated DG <15% of Peak Load on line section
3. For connection to a spot network: DG is inverter-based, aggregated DG capacity is <5% of peak load & <50 kW
4. Aggregated DG contribution to maximum short circuit current is <10%
5. Aggregated DG does not cause protective device to exceed 87.5% of short circuit interrupting capability
6. DG interface is compatible with type of primary distribution line (wye/Delta)
7. For a single-phase shared secondary, Aggregated DG capacity <20kW
8. Resulting imbalance <20% of service transformer rating of 240 V service
9. Aggregated transmission connected DG capacity <10 MW for stability-limited area
10. Construction not required for interconnection

Takeaway: The 15% Capacity Penetration metric has been shown to be far too strict in most cases

Common Utility Concerns for DERs

- **Voltage Regulation**
- **Protection coordination**
- Reverse power flow
- Unintentional islanding
- Increased equipment line duty
- Secondary network reliability
- Variability due to clouds
- Capacitor switching
- Impacts from multiple technologies



Common Mitigation Tools & Strategies

The Interconnection “Toolbox”

Modify protection settings/fuses

Advanced Inverter function use (e.g. absorb VARs to lower local voltage levels)

Power factor controls

Voltage Regulation Devices & Controls

Direct Transfer Trip (DTT)

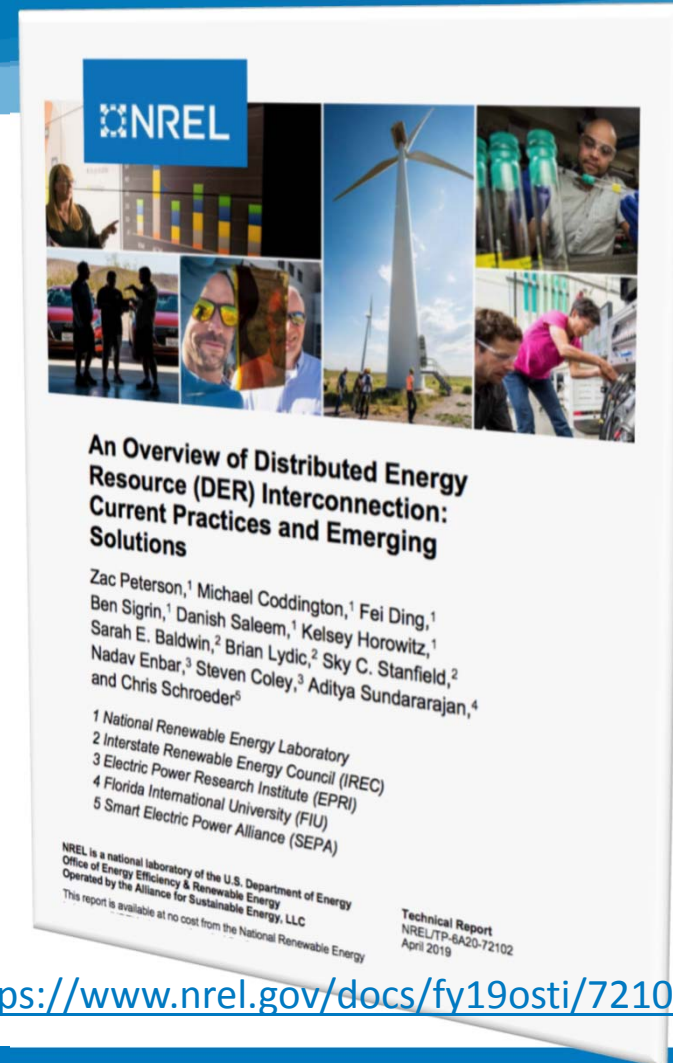
Upgrade a feeder or line section

Communications & Controls

Grounding transformers

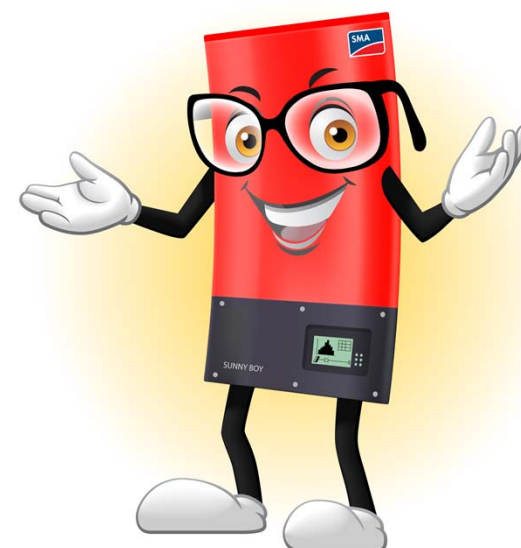
Limiting DER system size

Costs for each strategy vary greatly!



Smart Inverters – An Important New Strategy for Distribution Systems

- Power electronics that offer many additional features for control and grid support than the earlier inverters
- Many new smart inverter functions offer “Grid Support” features to help utilities
- The goal is to maximize the amount of inverter based DERs on the grid
- Utilities need all DERs to be “Grid Friendly”, and support voltage & frequency
- These inverters can provide future communication and control functions



Señor Smart Inverter

Major Achievements in 2018 Revision

- Consensus standard: 120+ industry experts in working group, 4-year effort
 - Robust public balloting: 389-member public ballot pool, 1,500+ comments resolved
 - 93% approval (75% required).
-
- More coordinated operation under normal conditions
 - Maintain grid safety
 - Grid support under abnormal conditions
 - New guidance for interoperability and open communications
 - New guidance for intentional islands
 - Strikes a balance between needs for large and small installations.

Final Observations – What Have We Learnt in the U.S.?

- Distribution Systems are generally able to absorb high amounts of PV and other DERs
- Potential challenges for PV (etc.) are related to size of DER system, DER location, voltage level of distribution system
- New technology, such as “Smart Inverters” and System Controllers will help increase “Grid Hosting Capacity” and allow greater DER penetration
- Monitoring and control for more DER systems will become necessary, but also autonomous controls will be critically important as distributed energy resources will become “Good Citizens of the Grid”
- Regulatory reform to support both DERs AND the utilities will be very important over the next few decades

Thank you

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