NREL
Transforming ENERGY

Hosting Capacity Analysis for **POLICY MAKERS**

NREL's dynamic hosting capacity analysis can help you better understand the thresholds at which new distributed photovoltaic (DPV) systems will trigger upgrades to the electrical distribution system.

The hosting capacity of a given feeder cannot be represented by a single number, but rather the point beyond which upgrades or control changes may be needed. NREL's analysis seeks to provide insights on this relational nature of hosting capacity and reveal how much DPV could be integrated using different control architectures and analysis paradigms (static, uncoordinated dynamic, and coordinated dynamic) and at what cost. This can shed light on trade-offs between different PV inverter settings, grid investments, or hosting capacity expansions.

NREL strives for transparency in its input data, methods, assumptions, and results. The table on the back outlines some of the pros and cons of each type of hosting capacity analysis

What NREL's hosting capacity analysis could do for you:

- Understand the potential costs and risks for utilities and developers associated with integrating DPV as a function of penetration level under different interconnection and control regimes
  - Use a transparent analysis as a starting point for discussions about integration options, distribution upgrade cost allocation schemes, longer-term business models, and regulatory policies
  - Provide DER developers with clarity, transparency, and flexibility around interconnection
- Understand the drivers of distribution grid integration costs and potential opportunities for research and development to drive down costs
- Analyze the potential options and distribution upgrades costs for reaching target penetration levels of DPV or DER.

	Static HC • Fit and forget • Worst case static snapshots	Uncoordinated Dynamic HC • Local autonomous control • No inverter communications • Probablistic screens	Coordinated Dynamic HC • Communications-based • Resolve multiple DERs and multiple constraints • Curtailment risk
Interconnection Solutions	• Traditional firm interconnection approach	• Firm interconnection with autonomous advanced inverter functionalities (for example, under IEEE 1547-2018 or CA Rule 21)	• Flexible interconnection, where curtailment risk is accepted by the PV developer as an alternative to paying for traditional distribution upgrades
Pros	• An established, simpler static hosting capacity analysis that required less computation and is less data-intensive • No curtailment risk for the PV developer	• Use of advanced inverter functionalities can allow for expansion of the hosting capacity at no cost to the utility • Captures time-dependent behavior of PV, loads, and grid devices	• May allow for the expansion of hosting capacity at a lower cost than traditional upgrades • Coordination between DERs could improve system performance, particularly at high penetration levels • Captures time-dependent behavior of PV, loads, and grid devices
Cons	• Static hosting capacity analysis does not fully capture the behavior of grid devices or controls and cannot be used to evaluate advanced integration solutions involving the dynamic control of PV inverters or grid devices • Some traditional upgrades may not be necessary if based on conservative snapshot power flow scenarios (e.g., if the PV only causes a small and temporary overvoltage)	• Dynamic hosting capacity analysis is more computationally- and data-intensive • Probabilistic screens inherently involve uncertainty	• Involves installation of communications infrastructure, monitoring, and software by the utility and/or the developer • Less predictable curtailment than with pre-defined autonomous functions • Certain principles of access may curtail a generator's output even when that generator isn't contributing to the constraint
Integration Strategies that Can Be Analyzed	• Traditional grid upgrades (e.g., adding voltage regulators with fixed set points, reconductoring, new transformers) and some advanced inverter functions (e.g., non-unity constant power factor, volt-var)	• Autonomous advanced inverter functions (e.g., volt-var, volt-watt) • Traditional upgrades may also be analyzed, including in combination with advanced inverter functions • Emerging grid upgrades that rely only on local control (e.g., D-STATCOM or D-SVCs)	• Coordinated control of PV inverter outputs and/or grid devices, under a variety of different control architectures • May be undertaken alongside broader grid modernization or smart-grid efforts • Traditional upgrades may also be analyzed, including in combination with advanced inverter functions
Types of Analysis Involved	• Steady-state power flow analysis under several snapshot conditions • Traditional analysis involved in the interconnection study process	• Quasi-static time-series analysis, including analysis of risk to the distribution system if inverters do not behave as expected • Analysis of curtailment risk may or may not be necessary • Curtailment risk can be avoided by inverter selection during the PV system design (e.g. oversizing the inverter kVA compared to kW to provide reactive power) if desired and economical for the developer	• Quasi-static time-series analysis, including analysis of risk to the distribution system if inverters and/or grid devices do not behave as expected • Assessment of curtailment risk for the PV developer involving quasi-static time-series simulation, ideally over a 1 year period or longer • Crucial to have a robust framework for understanding uncertainty from all stakeholder perspectives

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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

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