Hosting Capacity Analysis for **UTILITIES**

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.

Several different analyses can help utilities to understand whether a new DPV system will negatively impact a distribution system and trigger the need for distribution system upgrades or modifications. These analyses are typically done through the interconnection study and application process, but some utilities are also starting to use static hosting capacity analysis for other purposes, including the creation of hosting capacity maps to guide DER developers to low-cost and high-value locations.

Types of analyses typically performed include (see IEEE 1547; P1547.7 D110; IEC/TR 6000-3-7):

- Steady-state power flow analysis
- Dynamic simulation
- Electromagnetic transient analysis
- Harmonics and flicker studies
- Other protection analyses.

Steady-state power flow analysis has fed into hosting capacity analysis, which typically looks at when steady-state voltage and thermal violations would occur on the distribution system and require mitigation. In addition to over- and under-voltage events, voltage deviation is usually included as a hosting capacity metric as a proxy for flicker, but this is an imperfect metric.

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

- Understand potential system impacts of DPV as a function of penetration and potential low-cost mitigation options
  - Sequential hosting capacity analysis
- Understand different interconnection options that may be provided to your customers
  - Includes curtailment risk assessment
- Understand the potential trade-offs between cost and hosting capacity expansion for a range of possible distribution system upgrades that could be used to integrate DPV, including traditional and smart-grid investments
  - Sequential hosting capacity analysis, curtailment risk assessments, and distribution line loss analysis

NREL's hosting capacity analysis research is exploring traditional static and emerging dynamic concepts of hosting capacity that involve a different set of metrics and a probabilistic assessment. Dynamic hosting capacity accounts for the fact that under current ANSI standards, brief periods where voltage is outside Range A but inside Range B are allowed. NREL's analysis also considers that transformers have thermal inertia and can be overloading for a short period without causing problems. Comfort with these types of violations will vary by utility and many utilities don't have sufficient visibility to baseline what violations occur on their systems without DPV. NREL seeks to provides insights about potential hosting capacity and cost in these different regimes.

	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	• 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 can't 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 • Less predictable curtailment than with pre-defined autonomous functions • Different principles of access have different trade-offs in terms of risk and potential hosting capacity expansion
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

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