Understanding the Impact of PV and Other DER in the US Virgin Islands, Including Resilience Benefits

PRESENTED BY

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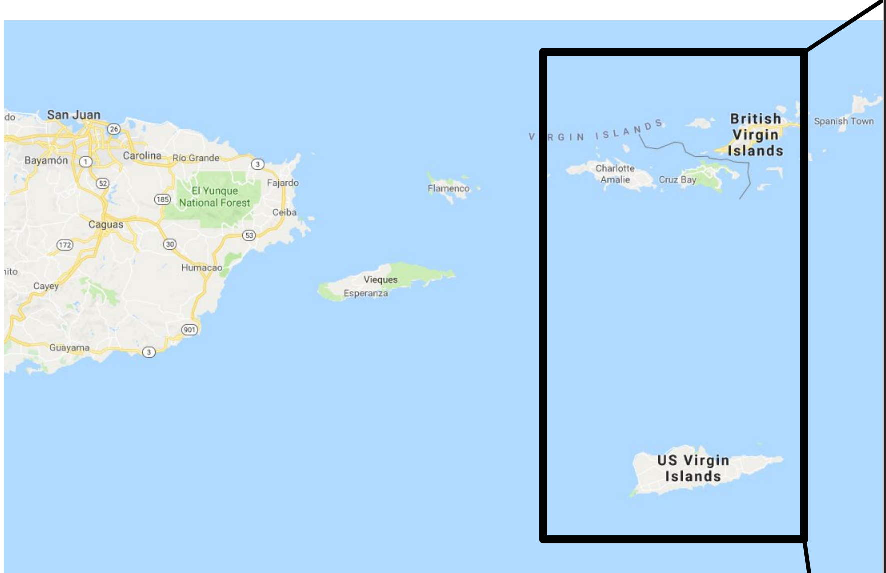
US Virgin Islands Layout and Population



Three main islands:

- St. Thomas (pop. 51,452)
- St. Croix (pop. 50,601)
- St. John (pop. 4,170)

US Virgin Islands Infrastructure

Powerplants:

- Harley (STT + STJ):
  - 150MW / 10 generators
  - 85MW peak load
- Richmond (STX):
  - 120MW / 6 generators
  - 50MW peak load

PV:

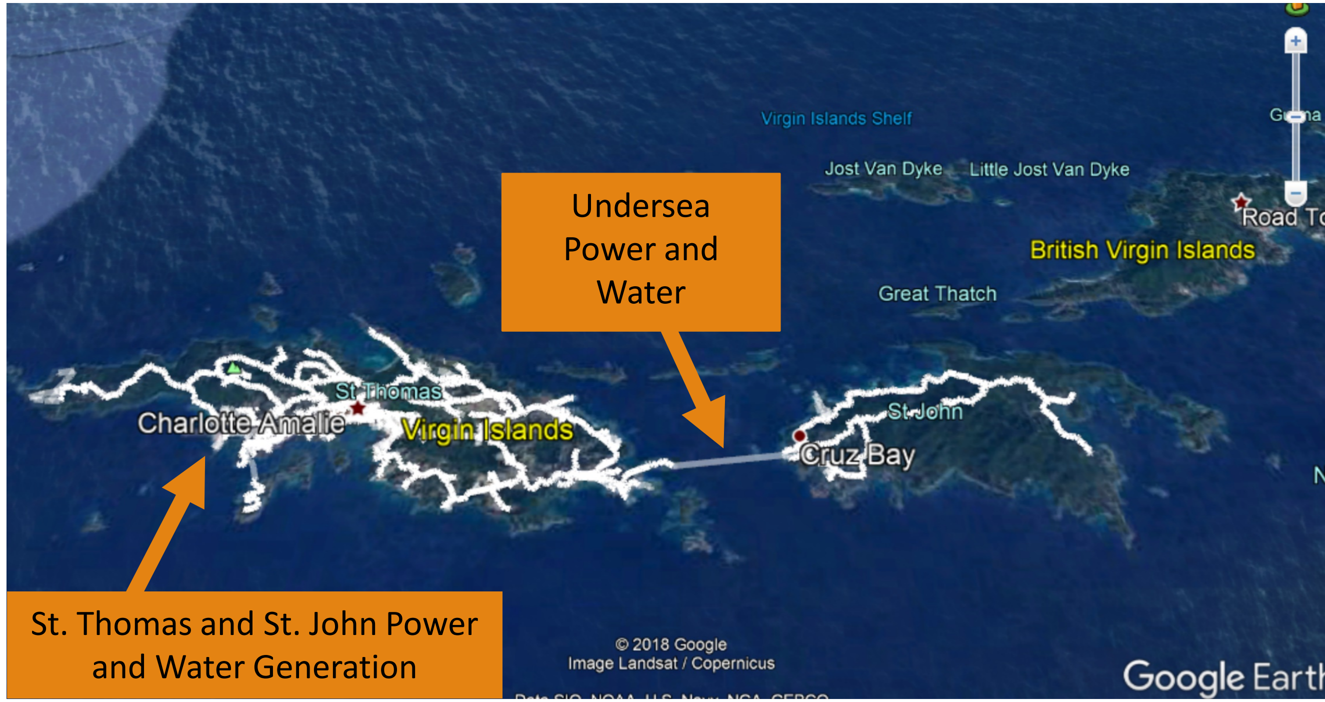
- STT + STJ:
  - 10MW net metering
  - 4MW utility-owned
- STX:
  - 5MW net metering
  - 4MW utility owned
- Co-located with streetlights: additional ~4MW distributed

Water:

- Serve ~30% of population
- STT: 3.3 MGD RO
- STX: 1.5 and 2.2 MGD RO

Communications:

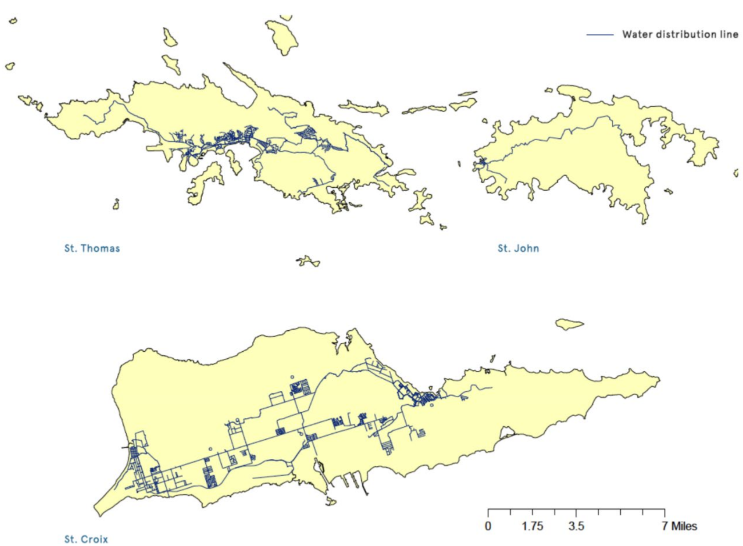
- Undersea cables



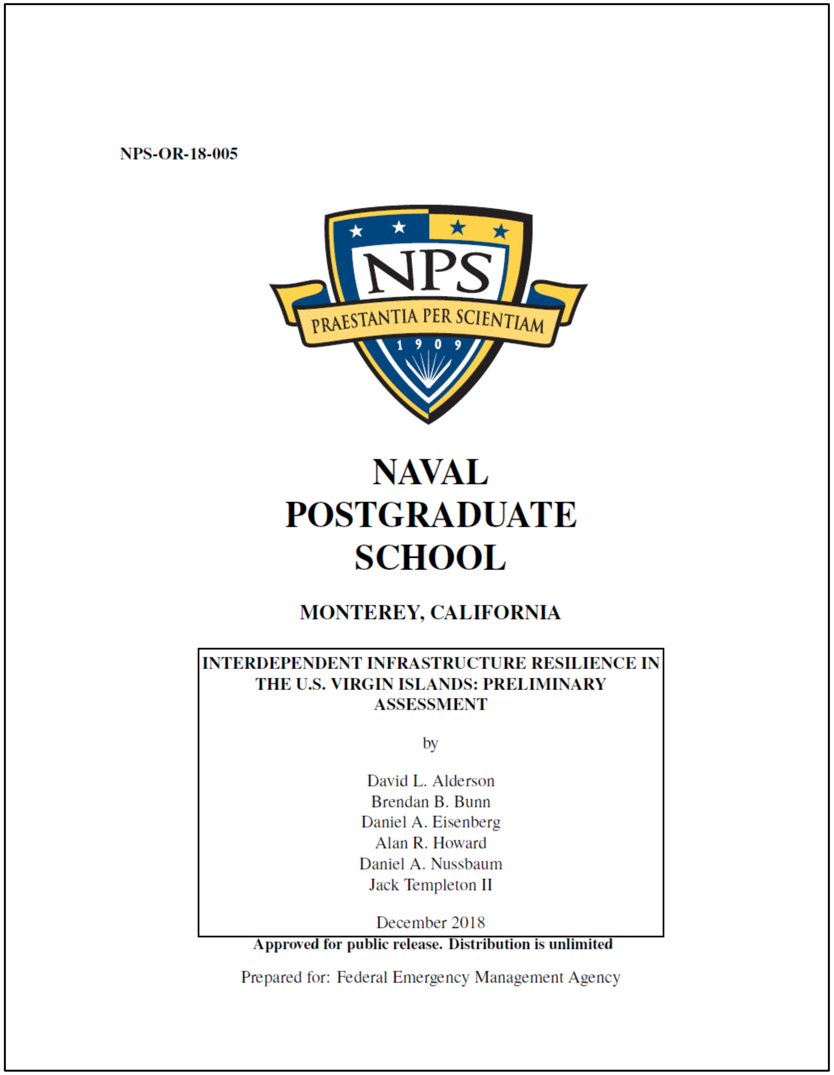
Interdependencies

- Power infrastructure is interdependent with other infrastructure
  - Water
  - Communication
  - Transportation

- Naval Postgraduate School (NPS) technical report has more details on USVI infrastructure and interdependencies



Alderson, D.L., Bunn, B.B., Eisenberg, D.A., Howard, A.R., Nussbaum, D.A., and Templeton, J., 2018, "Interdependent Infrastructure Resilience in the U.S. Virgin Islands: Preliminary Assessment," Naval Postgraduate School Technical Report NPS-OR-18-005, December. http://faculty.nps.edu/dlalders/usvi/NPS-OR-18-005.pdf



NPS-OR-18-005

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

INTERDEPENDENT INFRASTRUCTURE RESILIENCE IN THE U.S. VIRGIN ISLANDS: PRELIMINARY ASSESSMENT

by

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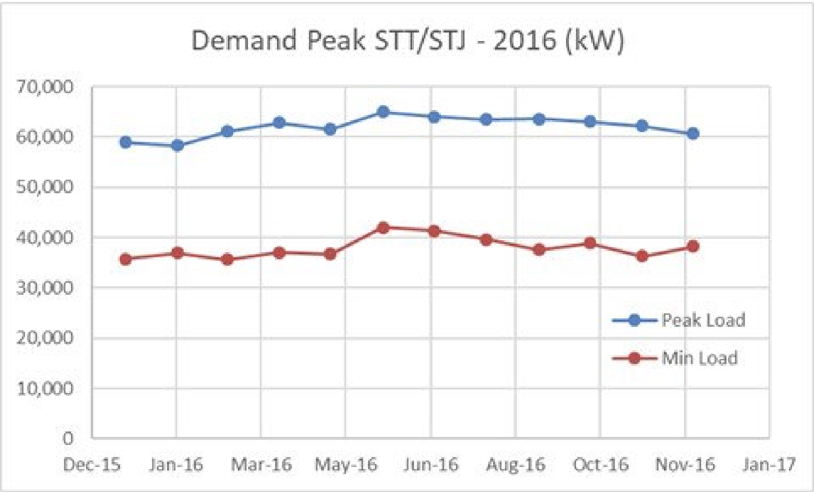
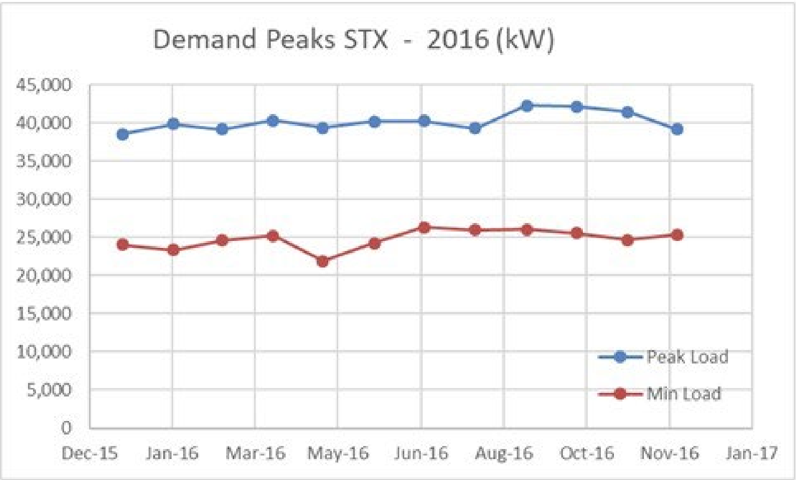
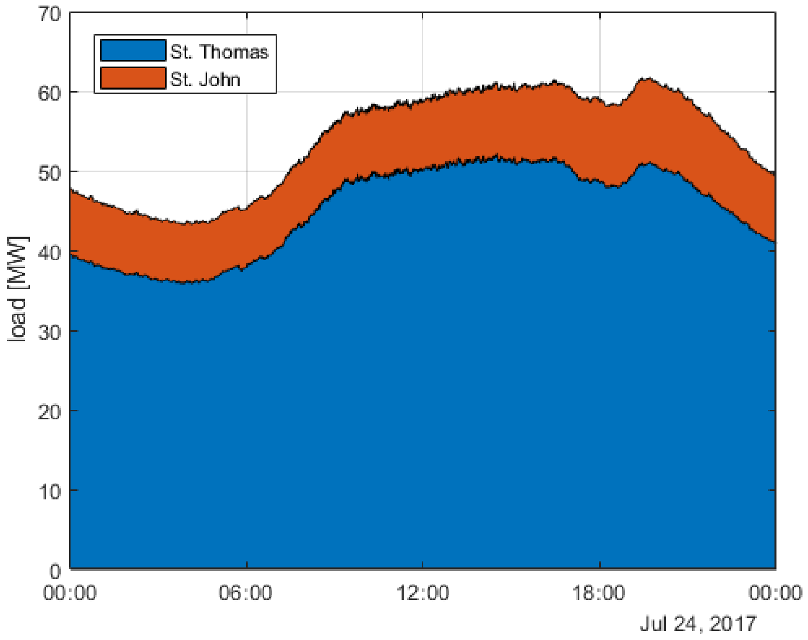
Approved for public release. Distribution is unlimited

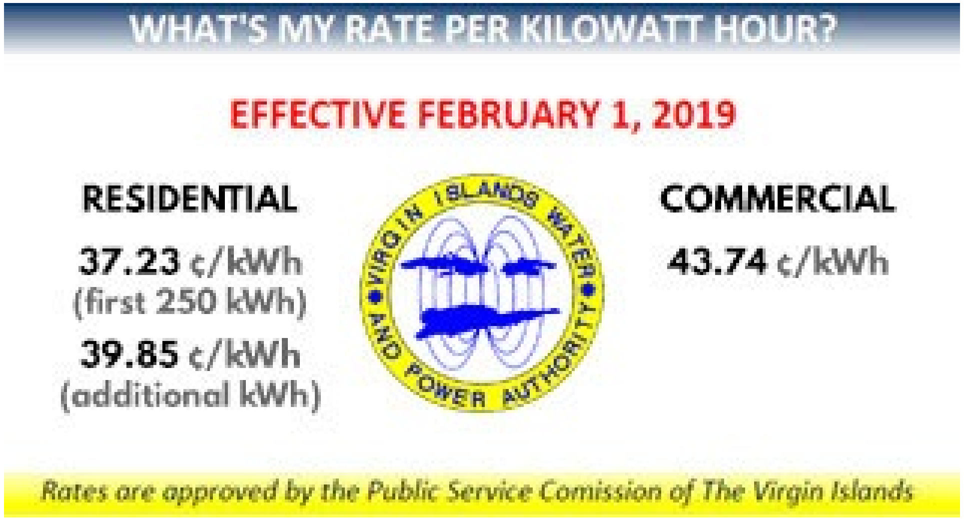
Prepared for: Federal Emergency Management Agency

US Virgin Islands Power Rates and Demand









Push for Reliable Power

- Blackouts are somewhat common in the USVI
  - One central generation location for each island system – single failures can result in blackout
  - Few, large generators with limited spinning reserves
  - Overhead lines are susceptible to damage
- Several residential customers have generators to maintain A/C, refrigeration, etc.
- Several industrial customers has switched to their own generation
  - Resorts
  - Oil refinery
  - Rum distilleries
- Increasingly challenging for utility to provide reliable power when high-value industrial customers leave grid

Push for Resilient Power

- Hurricanes Irma and Maria stressed the need for not just reliable but also resilient power
  - Nearly 100% of electricity customers lost electricity
  - Electrical transmission and distribution networks in the Territory were significantly damaged: 60% on St. Croix, 80% on St. Thomas, and 90% on St. John.
  - Electricity restored to 100% of eligible customers across the territory by January 2018.
- Companies with their own generation often restored faster
  - The Buccaneer Hotel (St. Croix) reportedly maintained power throughout the Hurricanes and was housing for FEMA responders almost immediately.

Opportunities for PV and other DER

- Distributed generation can increase system reliability and resiliency (and reduce costs)
  - Distributed generation reduces risk of single node failures
  - PV systems generally faired well during the hurricanes
    - Depending on location and quality of installation
  - PV does not require any fuel delivery
  - PV + storage systems can be sized and controlled to meet local loads
  - Lifetime costs are completive with or cheaper than other generation sources, and are less volatile since they do not depend on fluctuation fuel prices

4MW St. Croix PV system

55kW rooftop PV on hotel in St. Croix

Options for PV and other DER

Benefits
Challenges

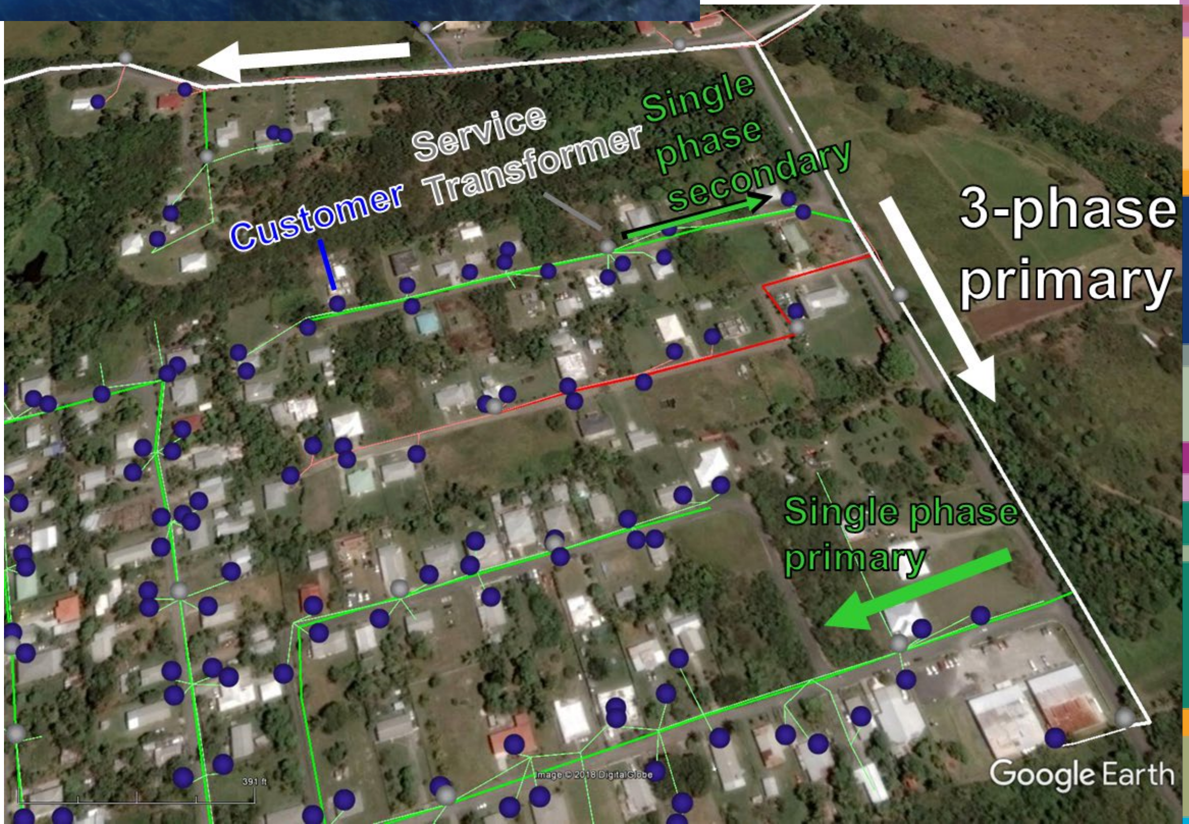
- Customer-Owned PV
  - Customers participate in energy market, take advantage of rooftop space
  - Lower costs to customers who adopt
  - Utility does not have visibility/control
  - Only benefits those who adopt PV
  - Need extra hardware (controls and storage) to provide power during a blackout
- Utility-Owned PV
  - Lower cost, benefit to all customers
  - Utility has visibility and control
  - Cannot use when the main grid is blacked out (need to sync with grid frequency)
  - Need large (flat) land area
  - Large capital projects for the utility to undertake
- Microgrids with PV and Storage
  - Prioritize critical loads
  - Serve power even when main grid is down
  - Can be grid-interactive – demand response or even sending power to the grid
  - Complex operation
  - Only benefit customers on the microgrid

Impact of PV to Grid

- Distribution grid modeling
  - Working with the utility, we have models of the USVI distribution grid infrastructure – lines, transformers, customers, regulators, switches, etc.
  - Models are implemented in OpenDSS
- Hosting capacity analysis
  - For each possible PV node on a feeder, add increasing sizes of PV until a problem is found
    - Voltage violation – per-unit voltage exceeds 1.05 or is lower than 0.95
    - Thermal violation – current flowing through line is more than the line's rating
    - Transformer violation – power flowing through the transformer is more than the transformer's rating
  - Hosting capacity informs both residential/commercial interconnection analyses as well as utility-scale PV connections
- Grid operation impacts
  - PV generation profile and its impact on net load and resulting impacts on storage and other forms of generation
  - Modeling of microgrids and their operation – PV + storage + grid demand, resulting voltage/thermal considerations, etc.

Distribution Grid Modeling

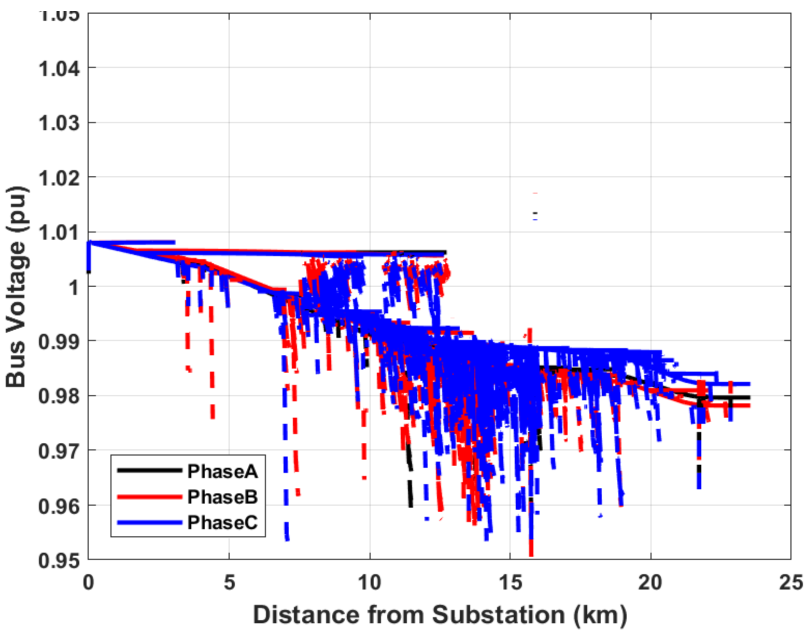
- Models include:
  - Primary system
  - Secondary system
  - Distribution transformers
  - Customers (loads)
  - Switches
  - Regulators
  - Capacitors



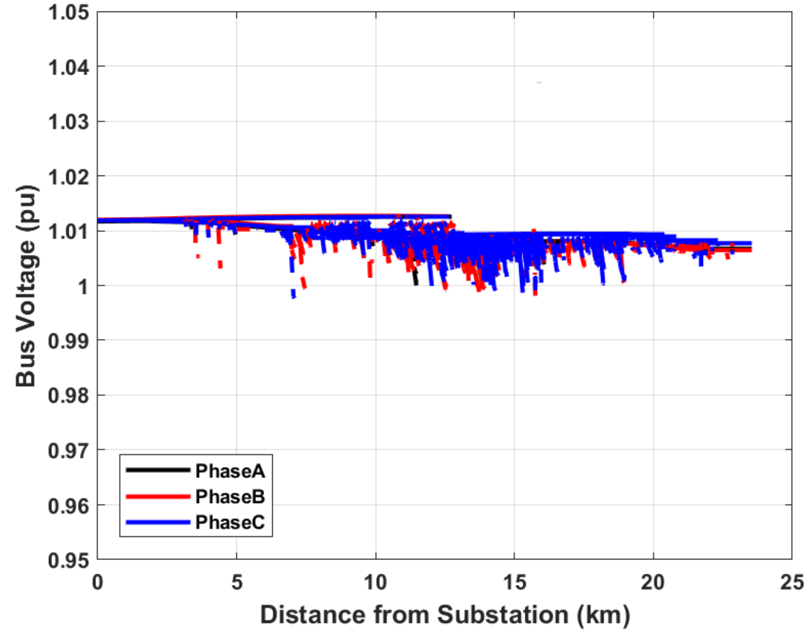
Hosting Capacity Setup

- For hosting capacity analysis:
  - High and low load scenarios are considered
  - Violations during *either* high or low load are considered as hosting capacity limits
  - The minimum PV size that causes a violation is the hosting capacity

High load (load multiplier = 0.95)

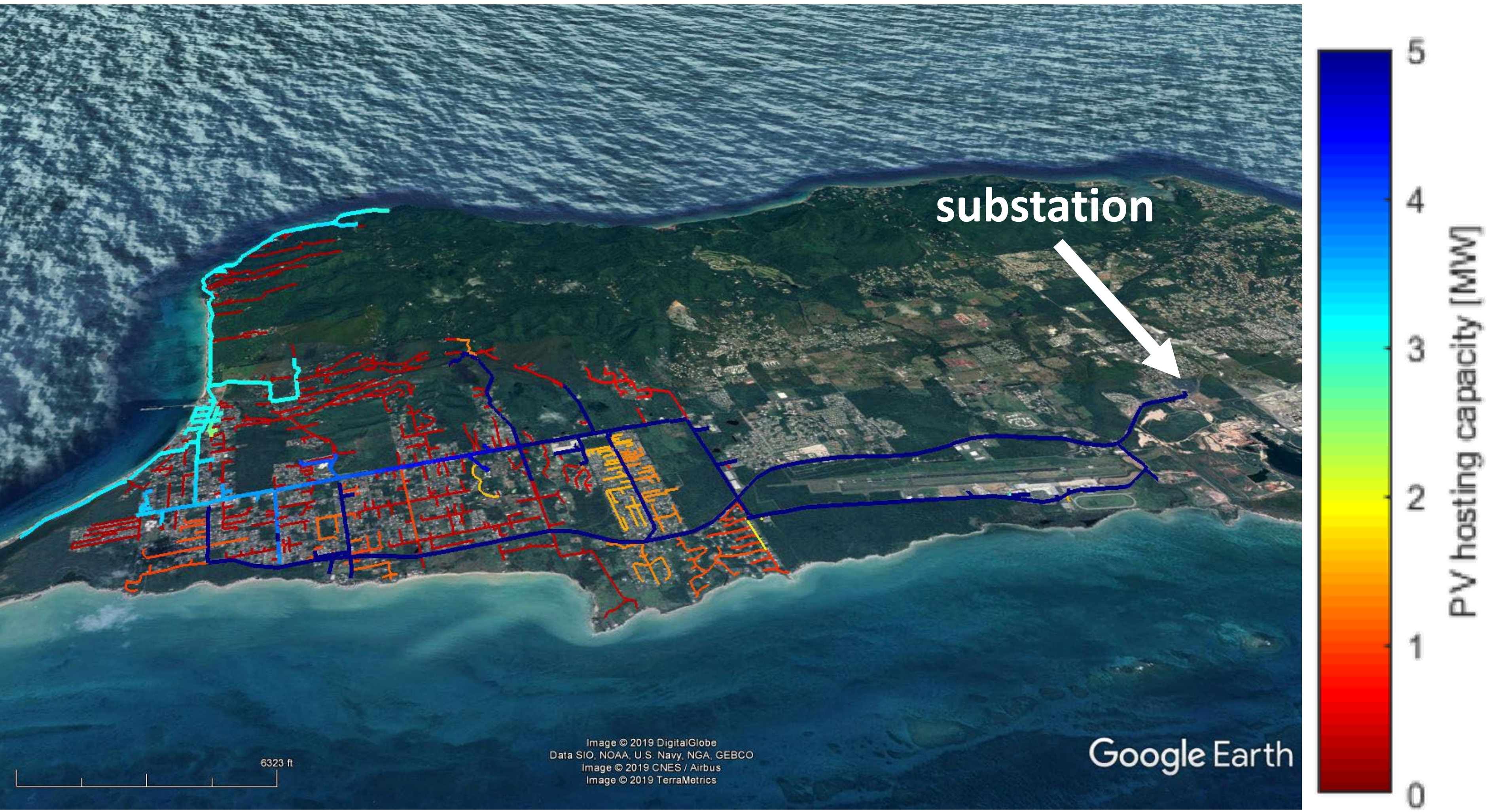


Low load (load multiplier = 0.28)



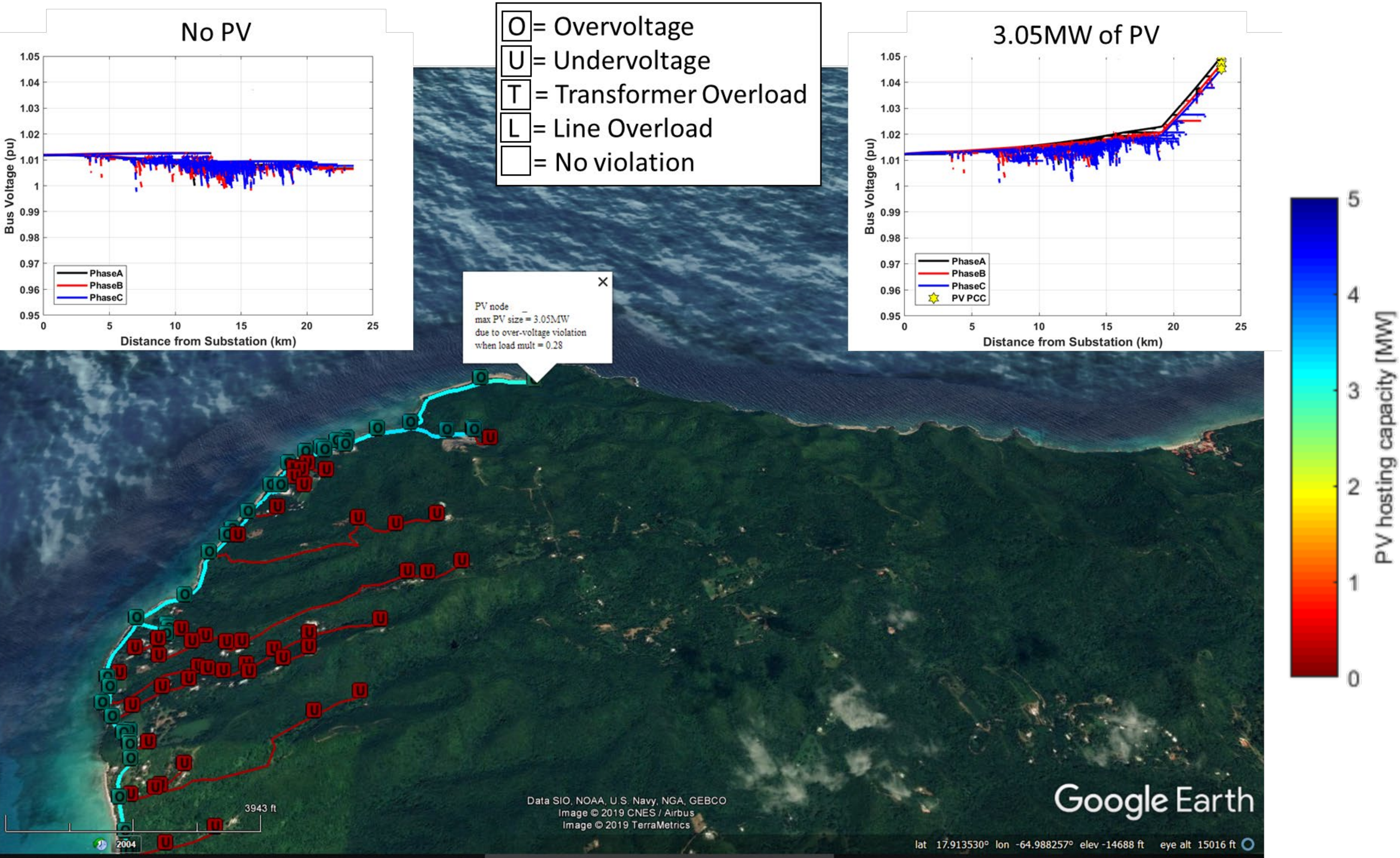
Hosting Capacity Results

- Hosting capacity generally decreases as traveling further away from the substation, and on single-phase lines



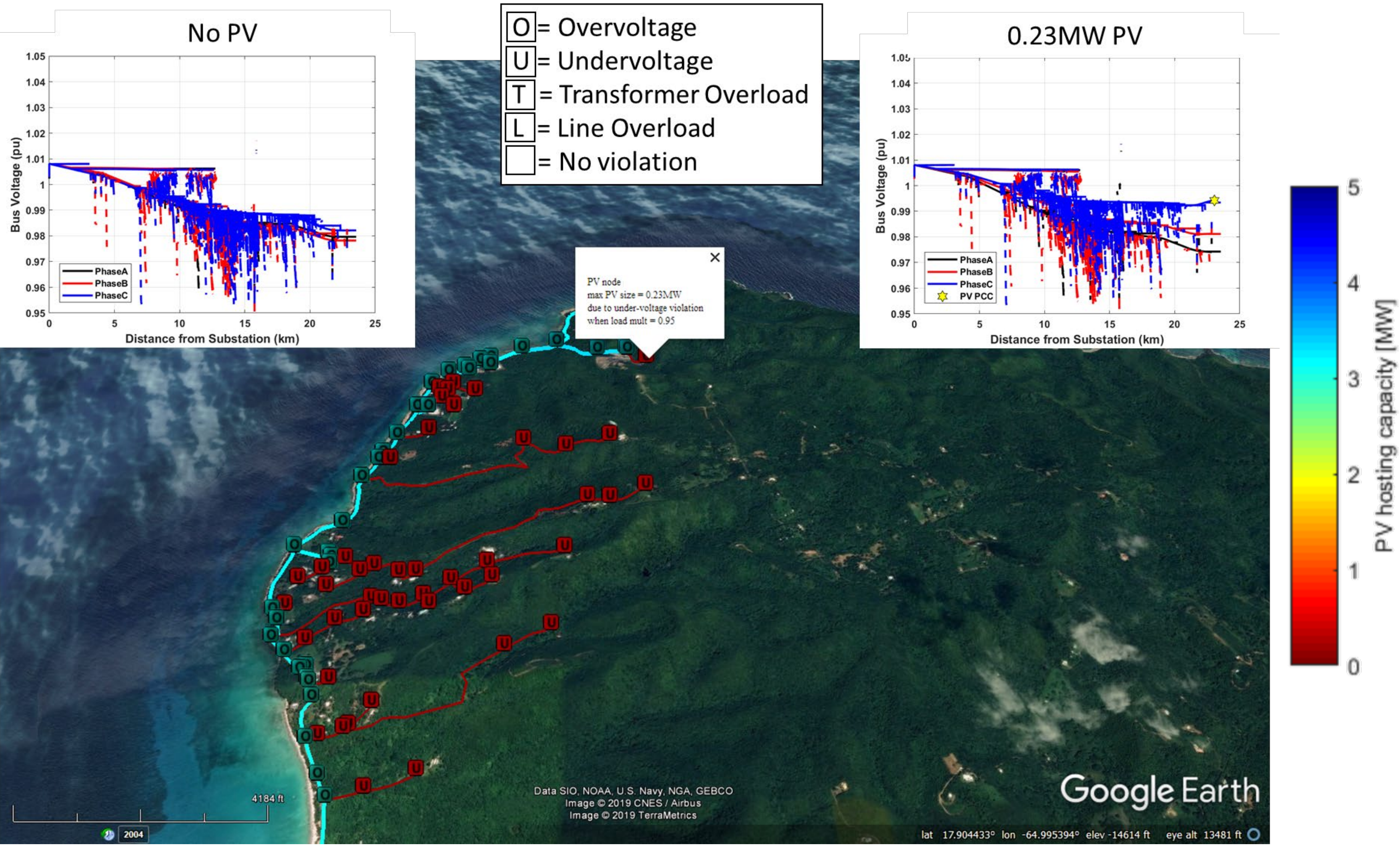
Hosting Capacity Results

- 3 phase node at end of feeder



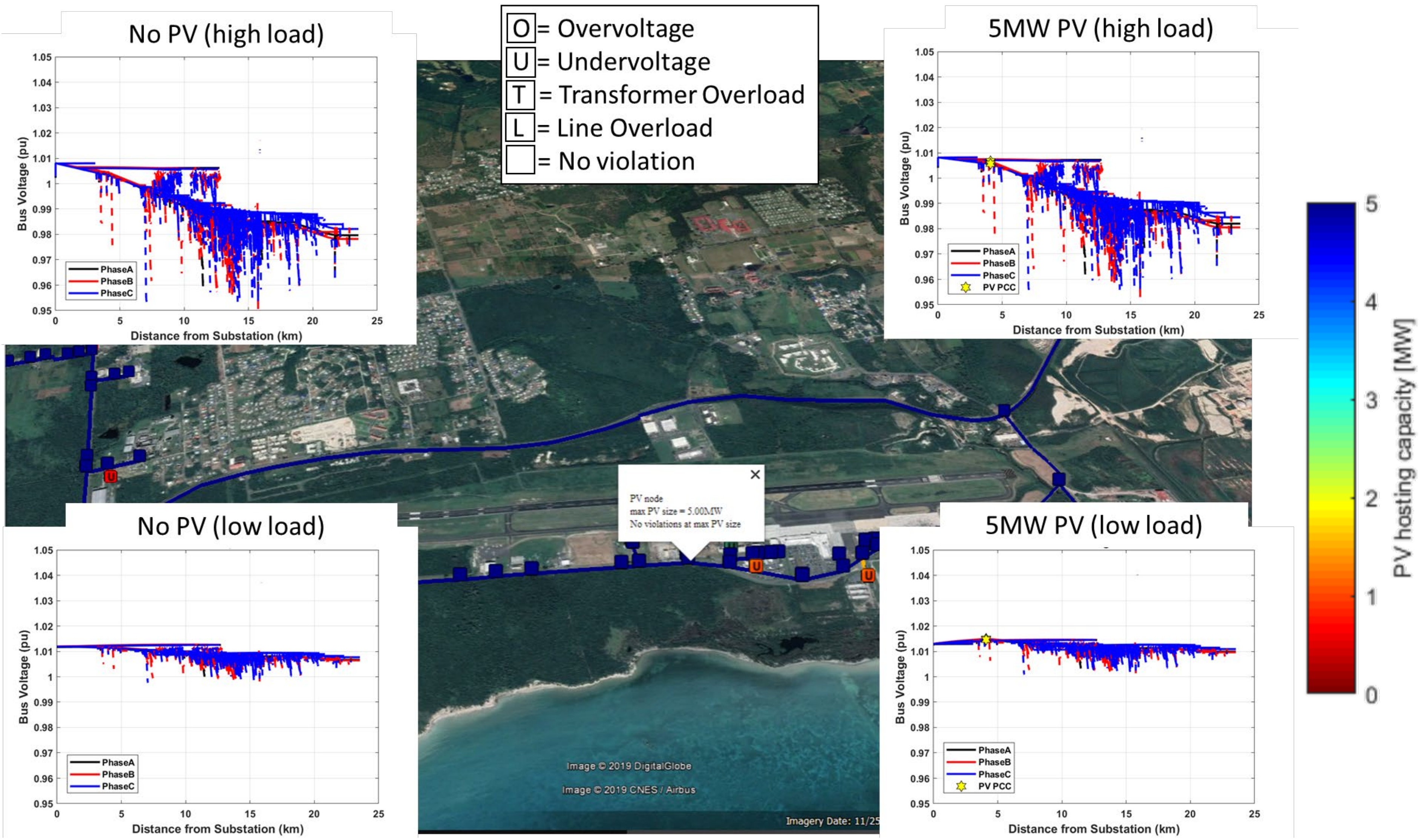
Hosting Capacity Results

- Single phase node at end of feeder



Hosting Capacity Results

- 3 phase node close to substation



Concluding Thoughts

- PV and other DER have the ability to increase
  - Reliability
    - do not need fuel deliveries
    - when paired with storage can provide nearly 100% availability
  - Resiliency
    - local generation generally can be restored much quicker than the main grid
    - PV systems are not susceptible to fuel supply vulnerabilities (e.g., lack of port access for diesel delivery)
    - PV integrated into microgrids can support critical loads
  - Cost-savings
    - PV can be cheaper than other generation sources
    - Limited operating costs beyond initial procurement – not sensitive to fuel price variability

- However, there are also technical, economic, and regulatory challenges
  - Technical barriers being examined, in part, through hosting capacity analysis
  - Economic challenges include ensuring utility solvency and benefits (reliability, resiliency, cost-savings) to all customers, not just those who can afford their own generation
  - Regulatory challenges include interconnection approval process, regulator and utility interactions, and aligning government and utility interests

Work is ongoing with colleagues from NPS, DOE, NREL, Berkeley Lab.