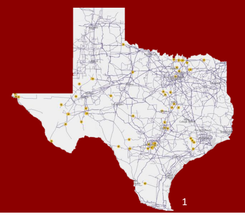

Using PV Inverters for Voltage Support at Night Can Lower Grid Costs

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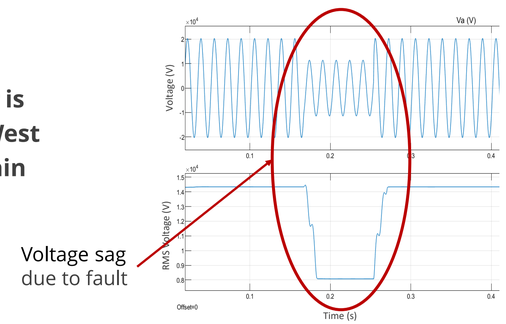
Radial transmission, such as those in West Texas, lines are susceptible to voltage excursions

If a fault or contingency happens, the voltage in that area and nearby areas drop quickly. Voltage excursions can be a result of the system's inability to meet reactive power demand[2].

Reactive power is needed 24/7 in West Texas to maintain grid voltage[3]



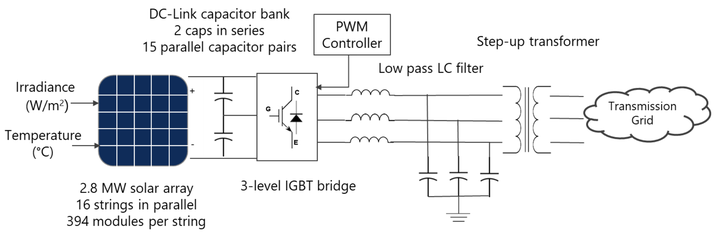
During the day, when the sun is shining PV plants can produce and consume reactive power to support voltage on the grid. At night, this support disappears, and the PV plants no longer provide that reactive power for voltage support. This has led to the installation of two expensive STATCOMs in West Texas in 2018, costing $70 million[3].

Can PV inverters be used at night to improve voltage on the grid and save system costs by avoiding the installation of a STATCOM?

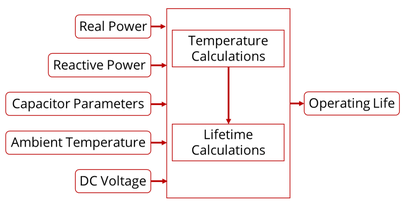
While PV inverters can technically operate at night[4], there are no policies or incentives in place to operate generators when they are not producing active power[5]. I examined whether current policies in ERCOT can updated to facilitate such use.

Methods

1) Find grid conditions that cause low voltages and determine if a PV plant providing reactive power resolves the voltage deviation, using power flow and contingency analysis
2) 2.8 MW PV plant model in MATLAB/SIMULINK to determine effect of reactive power on inverter



3) Calculate lifetime of inverter using simulation outputs and capacitor parameters



4) Determine the cost of inverter replacements with a discounted cash flow model

$$C_{VAR} = \frac{\sum_{n=0}^{N} \frac{INV_{qc,n} - INV_{c,n} + CTRL_n}{(1-r)^n}}{Q_{cap}}$$

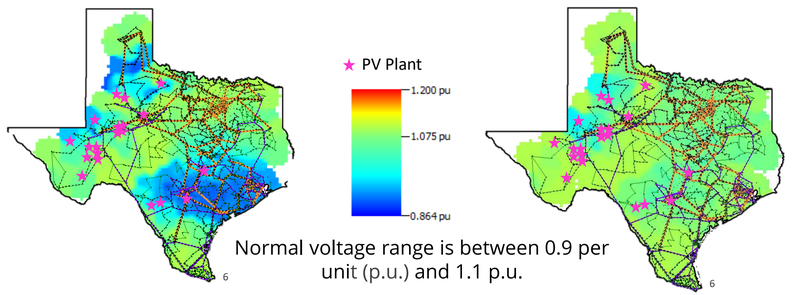
- INV_C - Cost of reactive power during the day
- INV_{qc} + CTRL - Cost of reactive power during the day and night
- Q_{cap} – total reactive power capability

Voltage profile is improved when PV plants provide reactive power support to the grid

Four busses brought back within voltage limits

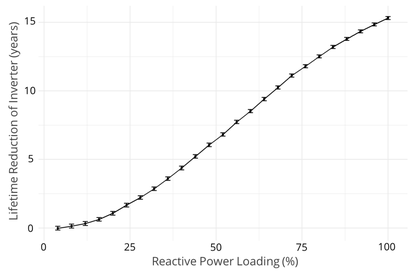
Post-contingency voltages **without reactive power from PV**

Post-contingency voltages **with reactive power from PV**



Normal voltage range is between 0.9 per unit (p.u.) and 1.1 p.u.

Lifetime Reduction of Inverter Providing Reactive Power Compared to Inverter Not Providing Reactive Power

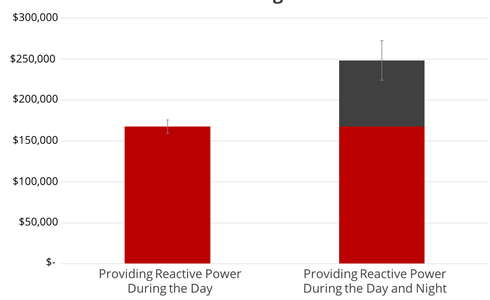


Providing reactive power at night reduces inverter lifetime by one year

Condition	Lifetime
No Reactive Power	25.9 ± 0.1 years
Reactive Power During the Day	24.6 ± 0.1 years
Reactive Power Day and Night	23.8 ± 0.1 years

PV generator owners already accept one year of lifetime reduction of their equipment for mandatory reactive power requirements

Cost of Reactive Power at Night from a PV Inverter

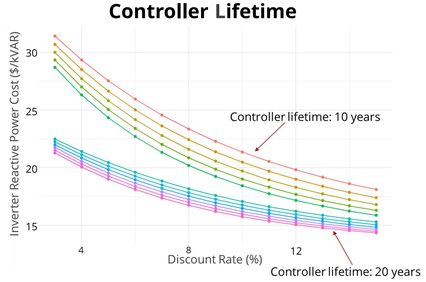


PV Inverter vs. STATCOM Costs

PV Inverter	STATCOM [7, 8]
$20.20 ± $0.40/kVAR	$77-$290/kVAR

PV inverters are $56-$269/kVAR or 4-15 times less costly than a STATCOM

Sensitivity Plot of the Discount Rate and Controller Lifetime



Conclusion and Policy Implications

- Inverters can provide the **same voltage support** as a STATCOM if purchased with an **augmented voltage controller**
- If a PV plant avoids the installation of a 50 MVAR STATCOM system capital expense savings amount to **$2.8 million - $13.5 million**
- ERCOT **should update their policies to include an ancillary service** for local reactive power that allows PV, and other generators, to provide voltage support when they are not producing real power
- If ERCOT updates their policies to allow for such an operation, the policy should **include the option for existing generators to opt out** to account for design and technology limitations

Drawbacks to Proposed Operation

- Existing PV plants may be unable to augment their voltage controllers
  - May not be an issue as 81 GW of solar in interconnection queue[9]
- The system needs redundancy for reliability
  - Rotating inverter outages can mitigate this issue
- Equipment outages (inverters, electrical equipment) happen unexpectedly
  - May cause overbuilding of inverters or installation smaller FACTS devices
- Utilities will have no direct control of the operation of the plant
  - Mitigated with increased communication and coordination

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