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QUANTA TECHNOLOGY

Value of Distributed energy resources (DER) to the distribution grid

10/30/18

Introduction and Background

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Policy Pushes for DER and Value to the Grid

Several States are Pursuing Formal Approaches to Valuing Distributed Energy Resources (DER)

- ✓ California – Locational Net Benefits Working Group under CPUC sponsorship
- ✓ NY – New York Renewed Energy Vision - legislation
- ✓ Illinois – Next Grid – legislation requires locational / hourly “value to the grid” avoided cost

The same concept is the starting point for all such efforts,

- ✓ Attempt to identify all the values that DER can bring including:
  - Energy cost savings
  - Emissions reduction and other environmental benefits
  - Local customer level reliability / resiliency
  - ***Avoided T&D capital and operating costs***
  - The avoided T&D costs are the “Value to the Grid” and a focus of much attention

This presentation summarizes recent and important work done to formally define a framework, analysis, and methodology for calculating the Value of DER to the Grid on a locational and temporal basis; such calculations can be used to establish the value of specific DER technologies as a basis for tariffs, capacity auctions, project selection, etc.

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Potential Value Created by a DER

CONSUMER	Total Energy Costs
	Demand Charges
	Consumer Green Lifestyle
	Consumer Back Up Generation
DISTRIBUTION SYSTEM	Distribution Capacity
	Voltage
	Reliability
TRANSMISSION SYSTEM	Transmission Capacity
WHOLESALE ENERGY MARKETS	Losses
	Congestion Costs
	Generation Energy
	Ancillary Services
	Resource Adequacy
	RPS Procurement
SOCIETY	Societal Avoided Costs
	Public Safety Avoided Costs
ENVIRONMENTAL	Emissions
	Waste Products
	Water Pollution
	Siting

- DER value is realized by various parties.

Value to Distribution Grid

- Several categories of value are potentially realized from DER
- Few value streams are associated with value to distribution grid
- Value streams realized are dependent on DER location and type

The Value of this Methodology

- ✓ **Efficiency:** Where DERs can provide a value to the distribution grid they should be compensated for doing so:
    - Deferring large investments to accommodate for changes in load or to increase renewable hosting, or to improve local reliability

- ✓ **Accuracy:** DER should be compensated for services they provide to the distribution grid
    - Address different characteristics/capabilities of different DER Technologies
    - Address differences in locational and temporal value of DER

- ✓ **Equity and fairness:** Limit impact to non-participating customers and avoid over-compensation and distorted market signals
    - Avoid double counting when some sources of DER value are compensated elsewhere
    - Non-participating customers should not be harmed in terms of cost or grid performance

Whether full avoided costs should be allocated to the particular DER or shared across all customers is a policy decision.

A spectrum of approaches

More Generalized ⟷ **More granular**

Fixed valuation	**Locational marginal value**	**Project specific**
DER is compensated by type, by circuit voltage level and by region	DER compensated based on distribution grid needs at a given location and time	DER is planned/engineered to mitigate specific grid issues and can be compared to traditional grid alternatives
Pros: Simpler, easier to understand and implement in the short term	**Pros:** More accurate and efficient; likely to lead to less cross-subsidies	**Pros:** Tied to specific projects; assigns DER compensation to where it has most value
Cons: Will over-value or under-value most DER	**Cons:** Might be more difficult to implement and understand	**Cons:** High Level of Effort & Best Suited for DER RFP Process

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Three Ways DER Provide Grid Value

1 **Real Power** →	✓ Providing locational load (capacity) relief by reducing net consumption during peak
2 **Reactive Power** →	✓ Providing voltage (volt-Var) support to maintain voltages within limits
3 **Reliability/ Reserve** →	✓ Providing standby capacity that can be used during emergencies or to backup variable DER

Current work deals with Real and Reactive power. A later phase may deal with reserves.

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Key Concepts

✓ The process

*If no violations, process stops here.

Traditional distribution planning stops here

Key Concepts

✓ The process

Develop forecast

↓

Identify binding constraints

↓

Traditional project to address constraints

→

Marginal Cost of Capacity (MCC)

- Marginal value of capacity products replaced by DER grid services
- Allocation of traditional investment to violations
- Full or partial mitigation

Distribution Locational Marginal Costing (DLMC)

→

Locational Marginal Value (LMV)

Sum of marginal value of DER for P, Q, R at any point in time

Key Concepts

Distribution Locational Marginal Costing (DLMC)

- ✓ Used to describe the value provided by a DER at a specific location at a specific point in time
- ✓ *Traditional approach:* LMV calculated by solving an optimal power flow (OPF) and calculating shadow prices of each violated constraint.
- ✓ *Our paper:* Direct LMV approach that bypasses OPF

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Value of DER Framework

1. Focus on the distribution grid: Calculates the Value of DER to the Distribution Grid only
2. Locational: Provides a mathematical formulation to calculate the Value of DER on nodal basis (using an Optimal Power Flow methodology) – *provides value of kW and kVar, deals with amp/MW capacity and voltage problems*
3. Compares DER to traditional investment: Provides a mathematical formulation to calculate the Value of DER compared to annualized cost of traditional distribution investment. (or other allocation of traditional project costs)
4. Accounts for distribution losses: Provides a mathematical formulation to calculate the impact of DER based on its locational contributions to losses for informational purposes
5. Considers temporal effects: Utilizes annual hourly ("8760") time-series analysis to calculate the Value of DER, which means that the time profile of DER output and different DER technologies will be considered
6. Output can be implemented at various levels of granularity: The methodology provides detailed engineering and policy means for the DER valuation
    - ✓ Depending on how we choose to implement it, DERs can be compensated at a nodal basis (more granular) or at various levels of aggregation along distribution circuits
7. Can be extended to all DER and should treat them fairly: Is resource agnostic – considers which core product the DER is able to provide, where and when.
8. Compensates real value to the grid: Avoid under/over compensation of DERs

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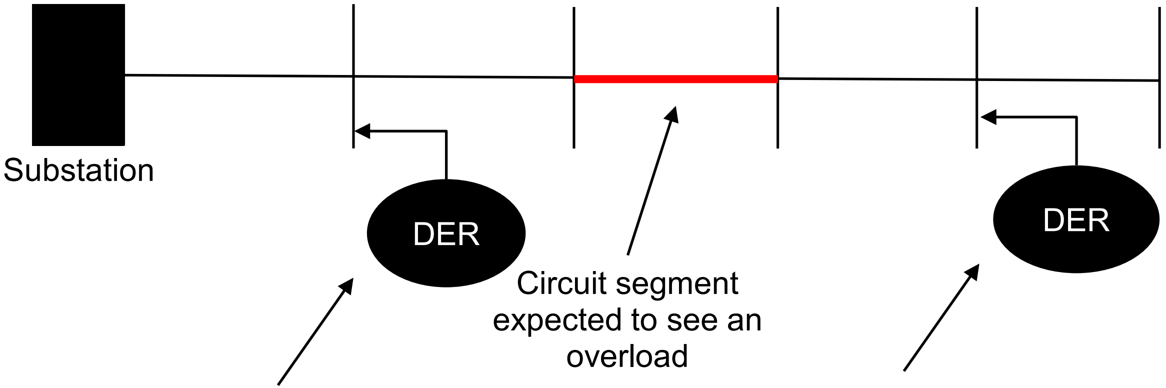
Value is Locational- "Vanilla" case



Upstream DER: Provides no value to mitigate projected overload.

Downstream DER: May be able mitigate projected overload depending on the DER type (i.e. generation pattern).

✓ If there are no constraints on the feeder (e.g. segment that is expected to see an overload), DER will have no value in deferring a distribution investment.

Value is Locational- Realistic case

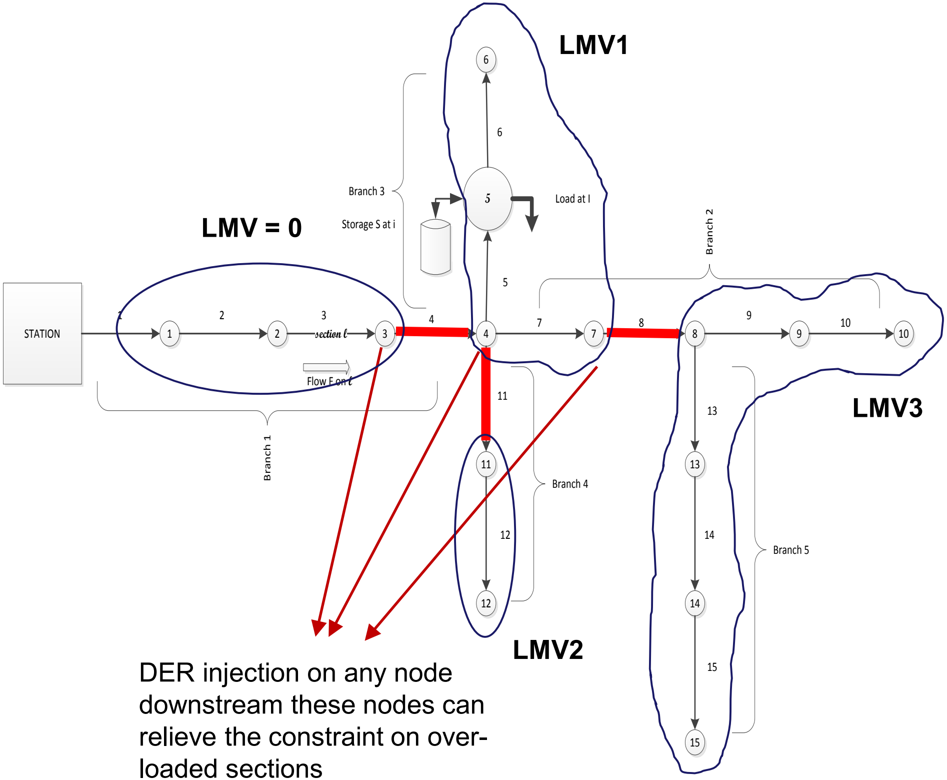
— Indicates over-loaded sections

✓ Three regions of non-zero LMV can be formed where:

LMV1 < LMV2 < LMV3

✓ Variation within each cluster is due to losses

✓ Difference between clusters depend on the amount of over-load on upstream sections



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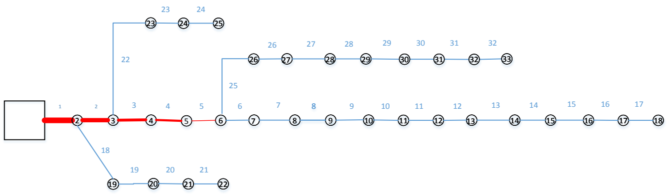
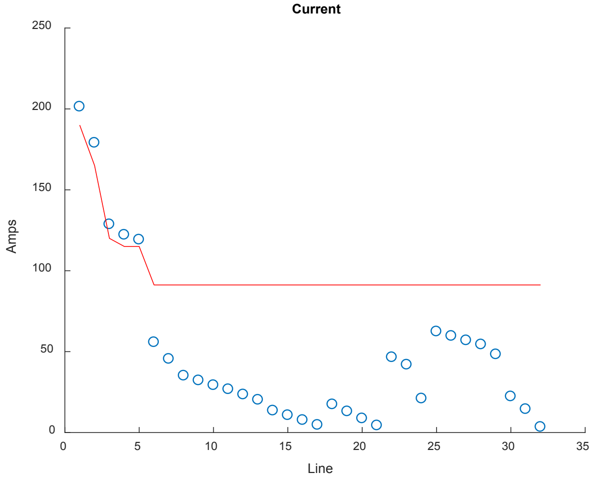
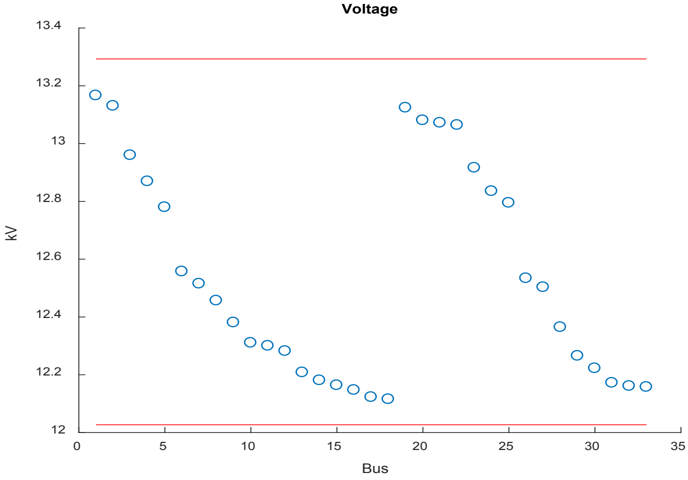
Case Study – IEEE33 bus

Overload Only

- ✓ 5 first sections are overloaded (3%-9%) and no voltage violation is present
- ✓ Total overload in amps is: 45.4 amps
- ✓ Total upgrade cost is assumed to be: $100k



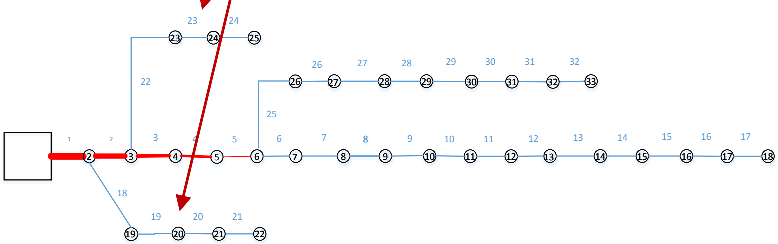


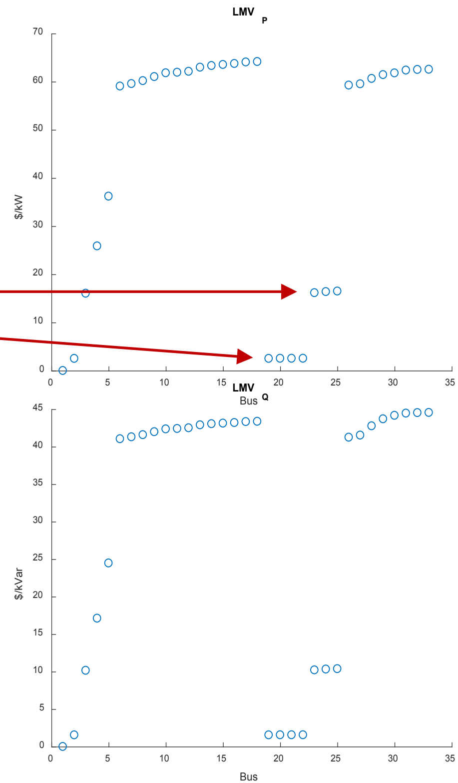


LMV

- ✓ Non-zero LMV starting at node 2 with an increasing trend both due to increased congestion and also increased MCC for lines with higher R (longer)

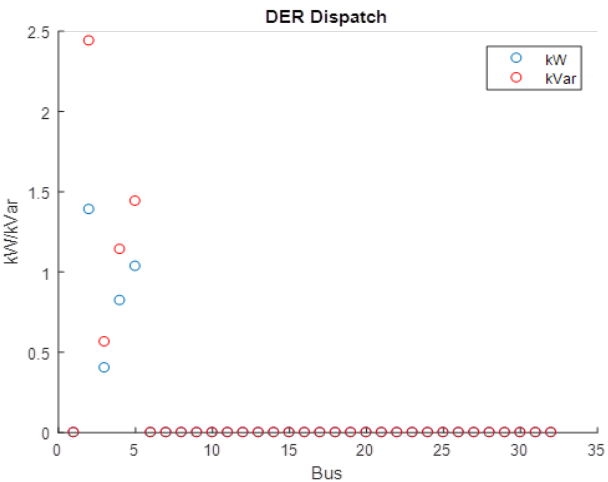
- ✓ Buses 19-22 and 24 and 25 have less LMV due to their limited contribution to overload relief of lines 1 and 2, and 1-3 respectively

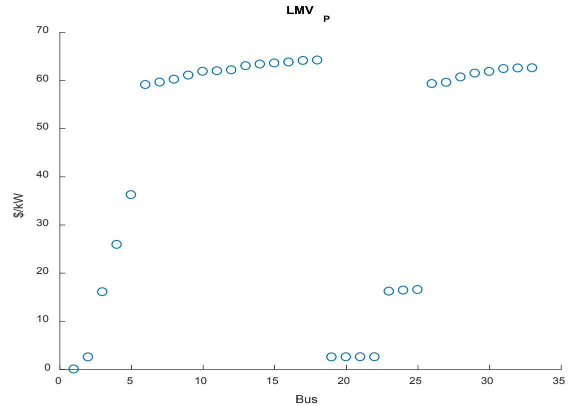


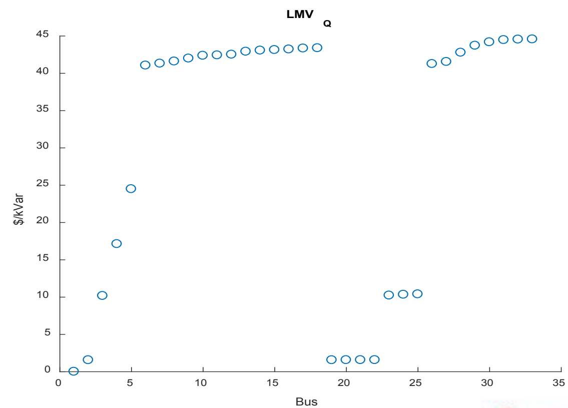


Optimal DER Dispatch

- ✓ Total DER cost = $\sum_j$P_DER(j)*LMV_P(j)+Q_DER(j)*LMV_Q(j) =$12,258
- ✓ Annualized upgrade cost = $12,000
- ✓ Upgrade Cost/DER Cost = 98%







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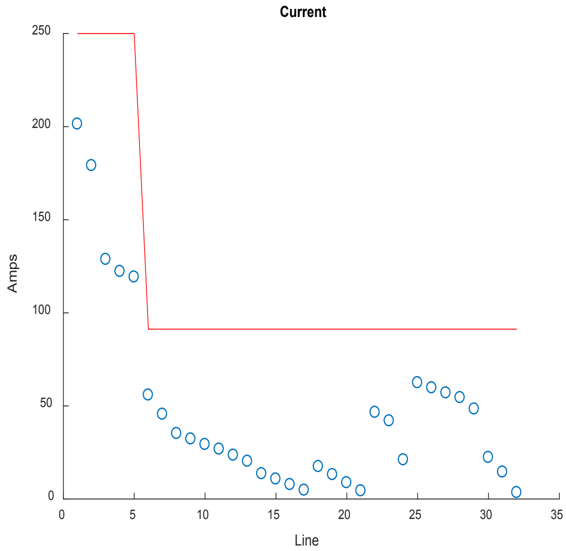
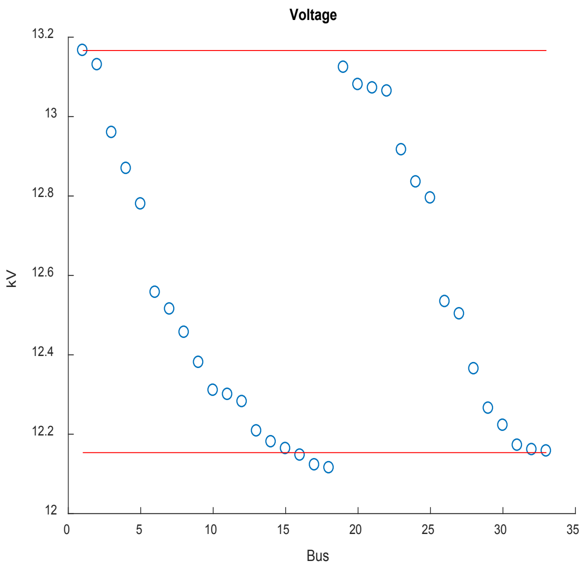
Undervoltage

- ✓ No overload but buses 16-18 have under voltage violation
- ✓ Total upgrade cost is assumed to be: $5k





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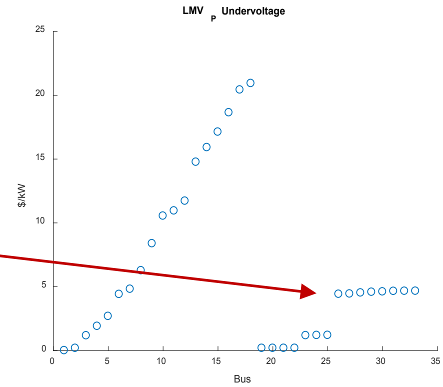
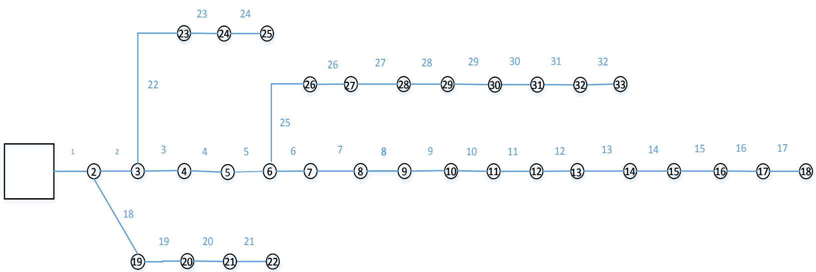
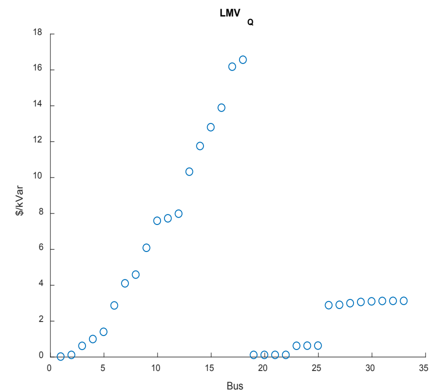
LMV

- ✓ Higher LMV at nodes 16-18 due to under voltage violation
- ✓ Low LMV in buses 19-35 due to limited contribution in fixing voltage issues



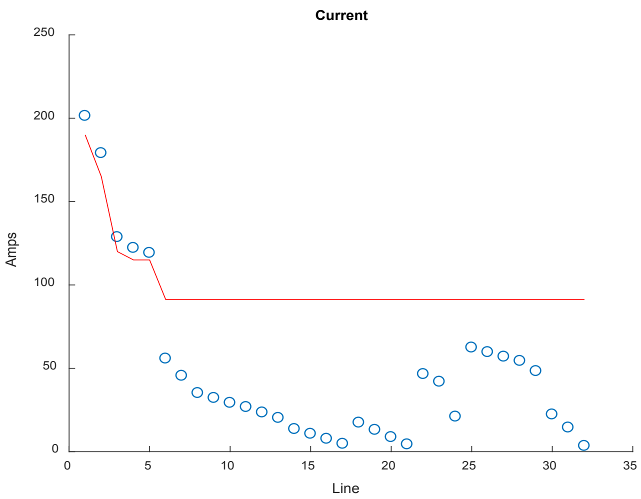


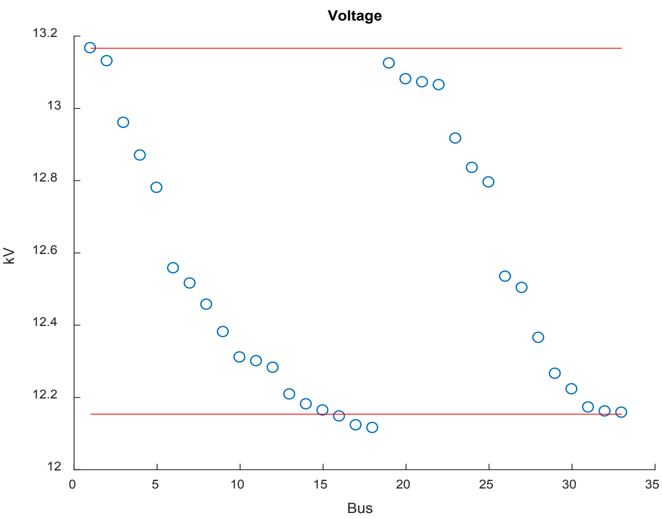


Why is LMV >0 at nodes 19-35 – they do raise the voltage on the whole feeder a bit

Overload and Undervoltage

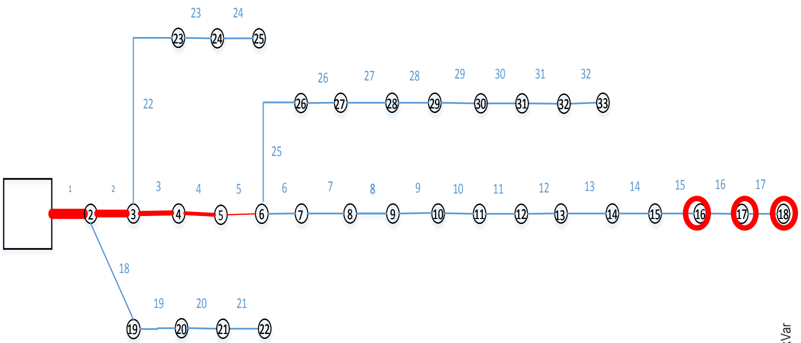
- ✓ Both overload and under-voltage violations are present
- ✓ Assuming separate projects for overload and under-voltage with the cost of $100k and $5k, respectively

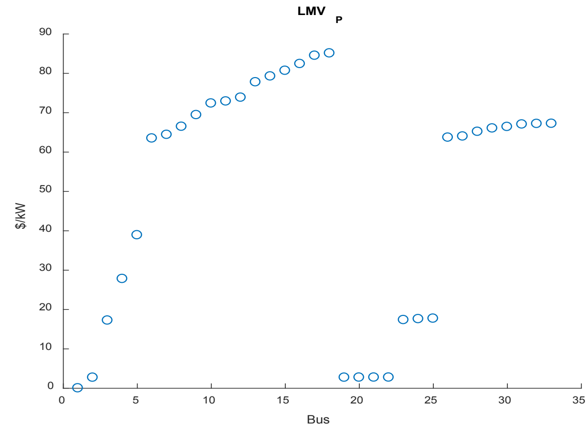


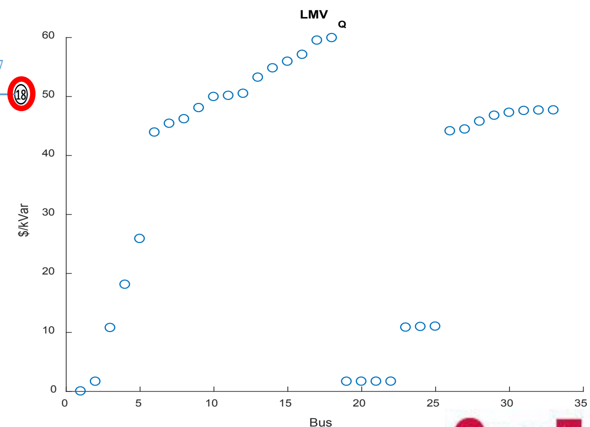


LMV

- ✓ Similar trend as in overload only case since overload is the primary driver
- ✓ LMV on buses 2-18 are slightly higher than overload only case due to under-voltage issue



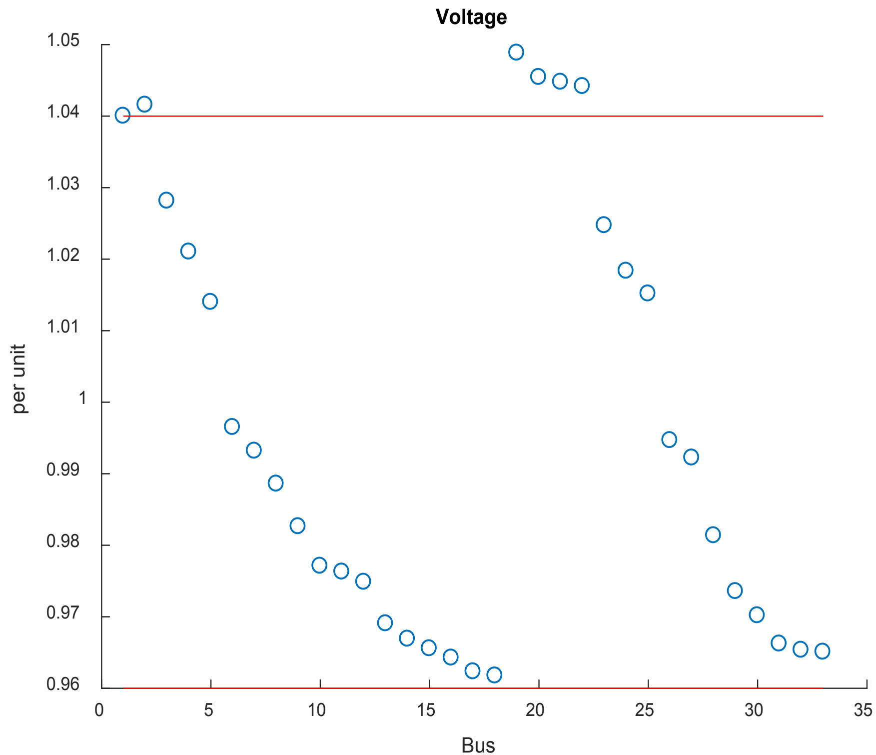




If the only "fix" is reconductoring then a mechanism (arbitrary) to allocate some MCC to the under-voltaged buses may be necessary

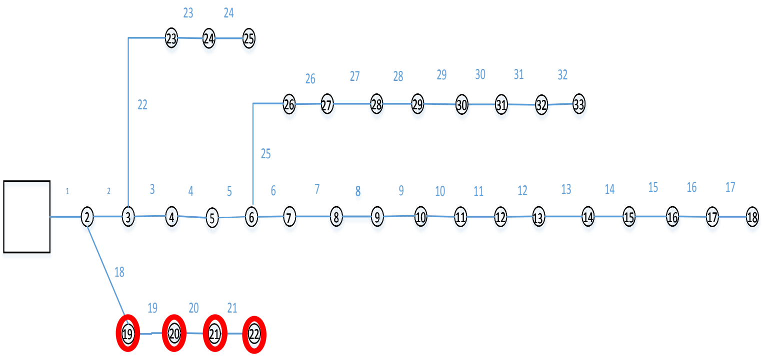
Overvoltage

✓ Buses 19-22 have over-voltage violations



LMV

✓ Over-voltage is on buses close to substation and lower impedance requires more withdrawal to fix the issue, therefore lower LMV than the under-voltage case



Counterintuitive but correct – because more –Q is needed, the value of 1 kVar is proportionately less