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Reducing Project CAPEX with Accurate Medium Voltage Cable Sizing

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BACKGROUND

Medium voltage (MV) cable sizing is a critical component of the balance of plant (BOP) design for any wind or solar project. The size of these cables has a significant impact on material costs and system losses, which influence project CAPEX and long-term project costs. It is the opinion of the author that many MV cable systems are designed with excessive conservatism, which means that it is possible to reduce upfront cable material costs. It is recognized that reducing cable sizes may increase electrical losses over the life of a project.

OBJECTIVE

- Clarify how the industry may be excessively oversizing MV cables.
- Examine the CAPEX reductions achieved by using more precise, accurate, and realistic engineering design practices.
- Discuss the long-term project cost implications from higher losses caused by reduced cable sizes.
- Help stakeholders understand the implications of cable sizing.

METHODS

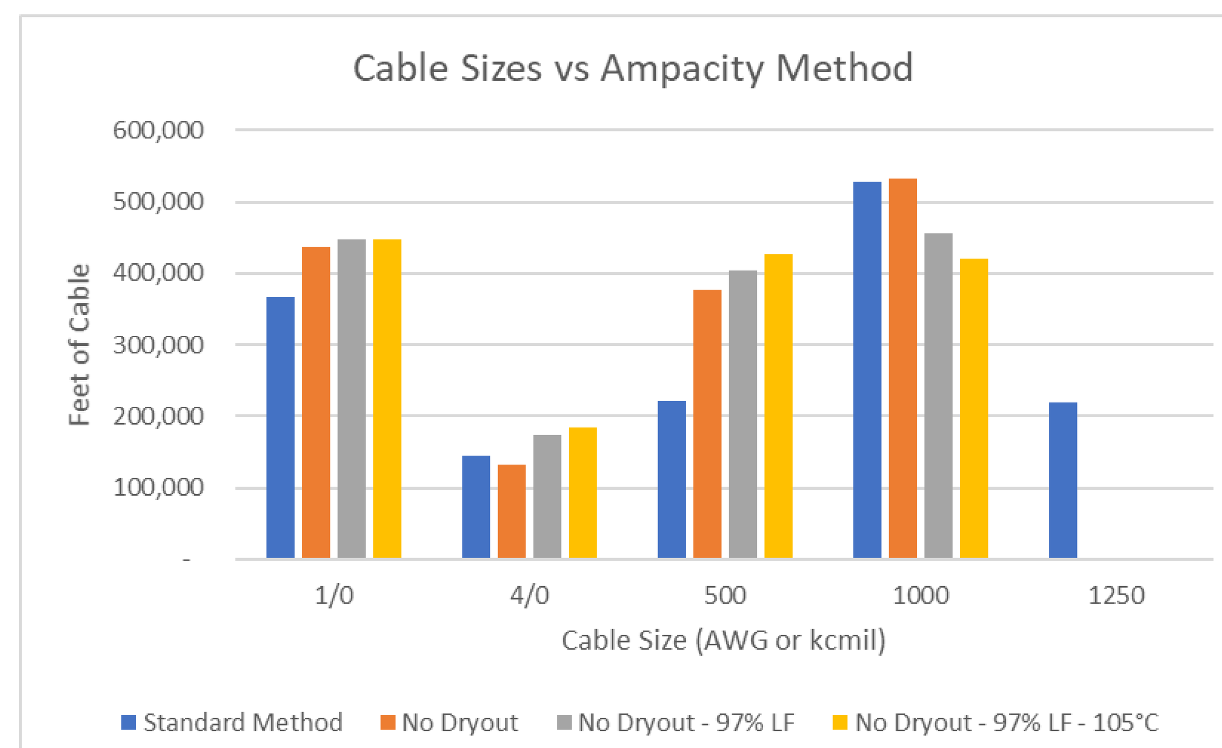
- Example 300 MW wind project
- Size cables using four different methods:
  - Standard method (with a dryout region)
  - Model only the recompacted trench (no dryout)
  - Model only the recompacted trench using a reduced load factor
  - Model only the recompacted trench using a reduced load factor and 105°C operating temperature
- Compare cable quantities for each cable sizing method
  - Note: short circuit withstand sizing was not considered in this exercise.
- Perform annual loss calculation with each set of cable sizes

RESULTS

Ampacity Methods:

- Standard Method – 90° C Operating Temperature
  - Native Thermal Resistivity = 105 ° C-cm/W
  - Trench Backfill Thermal Resistivity = 146 ° C-cm/W
  - Dry-out Thermal Resistivity = 241 ° C-cm/W
- No-Dryout Method – 90 ° C Operating Temperature
  - Native Thermal Resistivity = 105 ° C-cm/W
  - Trench Backfill Thermal Resistivity = 120 ° C-cm/W
    - Based on recommendation of geothermal testing contractor.
    - The testing contractor was provided with a maximum W/ft of heating losses in order to provide this recommendation.
- No-Dryout Method with 97% Load Factor – 90 ° C Operating Temperature
  - Analysis of wind distribution (8760) data results in a maximum daily load factor of 100% (the typical assumption)
  - Based on the C. Bates dissertation, a weekly load factor may be more appropriate for renewable energy projects. Calculating a running weekly load factor results in a maximum load factor of 97%. Applying this load factor to the ampacity calculation results in a 1-2% increase in ampacity (most impactful for the larger cable sizes.
  - Note that the 97% load factor occurred in February. The maximum load factor in the summer months was close to 80%, indicating that the cables considered in this exercise could be downsized even further.
- No-Dryout Method with 97% Load Factor and 105 ° C Operating Temperature
  - Most cable procured today on wind projects is rated for 105° C.

Cable Size	Cable Quantities Standard Method	Cable Quantities No Dry-out Method	Cable Quantities No Dry-out Method + 97% Load Factor	Cable Quantities No Dry-out Method + 97% Load Factor + 105°C
1/0	367,092	437,487	447,420	447,420
4/0	143,907	133,161	173,778	184,170
500	221,799	376,116	402,888	427,206
1000	527,214	532,998	455,676	420,966
1250	219,750	-	-	-

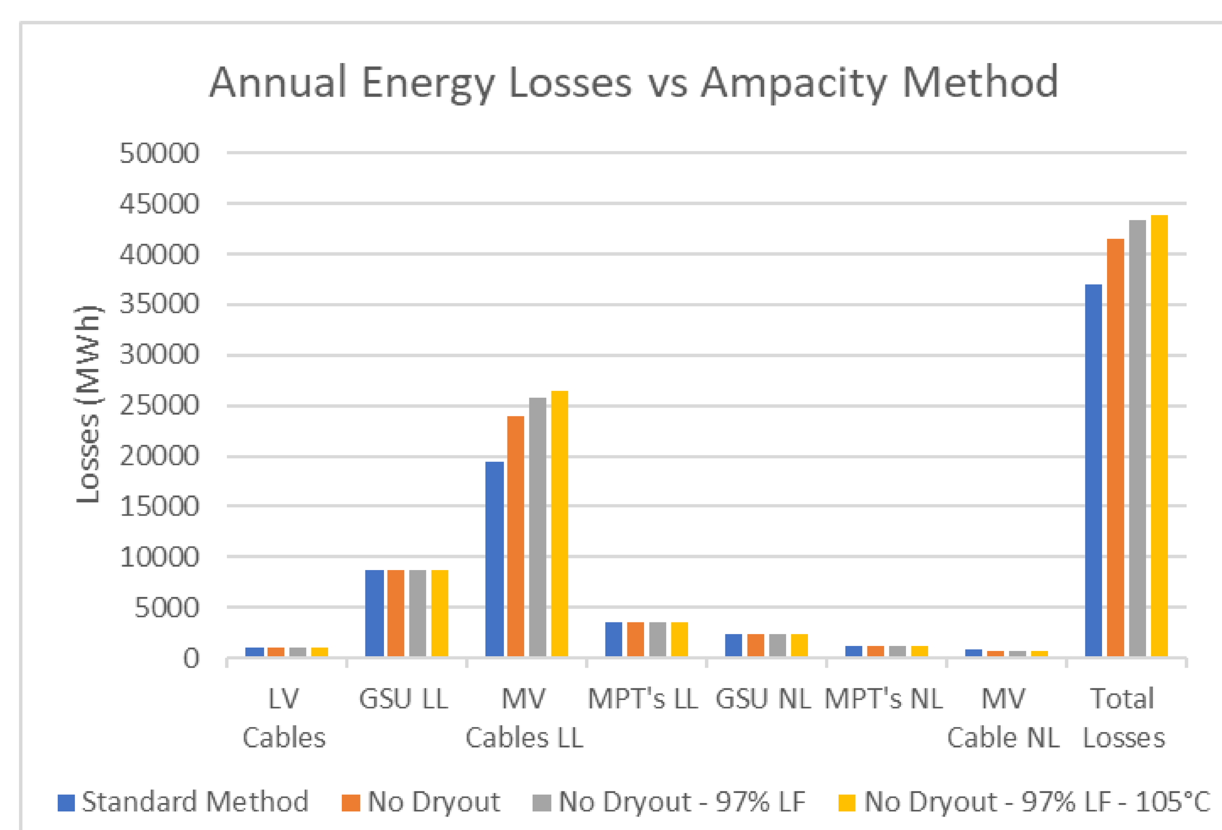


Cable Quantities:

- The standard method results in much larger cable sizes.
- As the ampacity method becomes more realistic, the resulting cable sizes shift to favor smaller sizes such as 1/0 and 500 kcmil.
- Significant upfront CAPEX savings may be gained by reducing cable sizes. This can be beneficial to certain stakeholders:
  - Developer
  - Contractor
  - Owner if CAPEX is a concern

Annual Energy Losses:

- Reducing cable sizes increases annual energy losses by 6,847 MWh (comparing standard method with the most aggressive method).
- Assuming 20$/MWh PPA, this result in an annual loss of approximately $137K.
- Depending on project life and NPV calculation, it may not be in the best interest of the owner to reduce cable sizes.



CONCLUSIONS

- Cables are being significantly oversized using prevailing ampacity calculation methods.
- Using more precise ampacity calculation will reduce upfront CAPEX
  - Beneficial for contractors, developers, or any party desiring to reduce upfront cost
- Reducing cable sizes results in a material increase in annual energy losses.
  - Negatively impacts the long-term owner of a project
  - Owners should perform net present value to determine optimal cable sizes

Future Work

- Perform parametric analysis to determine worst case ampacity during the various seasons – load factor vs ambient temperature.
- Perform a more detailed load-profile simulation to substantiate the use of a weekly load factor.

ACKNOWLEDGEMENTS

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REFERENCES

C. Bates, Underground Cable Ampacity: A Fresh Look at Addressing The Future Electric Grid, Colorado School of Mines, 2018.

CONTACT INFORMATION

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