CADMUS

MASSACHUSETTS DOER COMMUNITY CLEAN ENERGY RESILIENCY INITIATIVE
MICROGRID INTERCONNECTION COST ANALYSIS

Overview

HOMER Energy developed a summary of the expected cost ranges for the various components of interconnecting microgrids. The costs split, nominally, into wiring costs (which correlate most closely with the distance installed) and equipment and balance-of-system costs (which correlate most closely with the system's rated installed capacity). The itemized component costs follow, summarized into subtotals that can be used for planning purposes.

An order-of-magnitude estimate of effort for refining these preliminary costs into site-specific costs is $5,000 to $20,000 per interconnection required in the microgrid, based on 5 to 20 days of effort from a qualified and experienced engineering firm at $1,000/day.

Category	Parameter	Cost Low	Cost High	Units	Factors Influencing Cost Range
Wiring	Dist. wire costs, installed, overhead[1]	$15	$621	$/m	• Are new poles necessary or may existing poles be used? • Right-of-way issues. • Obstacles preventing straight line run. • Power (especially as a function of high amperage).
	Dist. wire costs, installed, underground[2]	$60	$2,796	$/m	• Underground is substantially more expensive than overhead. • Are new tunnels/conduit necessary or may existing infrastructure be used? • Right-of-way issues. • Obstacles preventing straight line run. • Power (especially as a function of high amperage). • Hydrology. • Geology: difficulty of tunneling/running conduit.
Protection	Protection[3]	$50	$200	$/kW	• Complexity of internal circuit. • Radial vs. network. • Number of generation/storage sources. • Number of connections/loads.
	Monitoring, communications, and control[4]	$100	$200	$/kW	• Complexity of internal circuit. • Radial vs. network. • Number of generation/storage sources. • Number of connections/loads. • Data needs: minimal through research level.
Switchgear	Switching and synchronization[5]	$200	$500	$/kW	• Manual vs. automatic. • Automatic: seconds vs. cycles to subcycle. • Both: synchronization requirements.
Energy Management	System, hardware, software, display[6]	$100	$300	$/kW	• Do the power and energy available support the entire load? • If not, are multiple high-priority circuits required? • Multiple levels of priority? • Are priorities dynamic? • Complexity of the circuit and architecture?

Category	Parameter	Cost Low	Cost High	Units	Factors Influencing Cost Range
	Wiring/switching high-priority circuits	Highly site and end-use dependent			• Are high-priority circuits already isolated/separated?
Transformation	Transformers	$30	$150	$/kVA	• Only necessary for longer connections at lower voltages. • Cost range is a function of efficiency class.
Subtotal $/m	**Range if above-ground wiring**	**$15**	**$621**	**$/m**	• Cost range from expanding existing poles through new installation in an urban area with right-of-way issues.
	Range if buried wiring	**$60**	**$2,796**	**$/m**	• Cost range from expanding existing tunnels/conduits through new installation in an urban area with right-of-way issues.
Subtotal $/kW		**$480**	**$1,350**	**$/kW**	• Simple manual switch without sophisticated energy management through automatic subcycle switching with: high power quality, sophisticated dynamic energy management, and voltage transformation for longer distance distribution.

[1] U.S. low voltage trans; 10–25MW capacity is $15,000–40,000/km. Dixit, K., Baldick, R. An empirical study of the economies of scale in AC transmission line construction costs. Manuscript, unpublished. 2003. Available online at: http://www.eei.org/issuesandpolicy/electricreliability/undergrounding/Documents/UndergroundReport.pdf
[2] http://www.elp.com/articles/powergrid_international/print/volume-18/issue-2/features/underground-vs-overhead-power-line-installation-cost-comparison-.html and http://www.eei.org/issuesandpolicy/electricreliability/undergrounding/Documents/UndergroundReport.pdf
[3] http://www.districtenergy.org/assets/pdfs/03AnnualConference/Monday-A/A5.2SANCHEZIvette-Sanchez-IDEA.pdf, http://energy.pace.edu/sites/default/files/presentations/downloads/MG_WS_3_JKelly.compressed(1).pdf; http://e2rg.com/microgrid/switch_breakout1.pdf
[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/dt_prelim_tsdchp10.pdf

Discussion and Conclusion

As noted in the table, costs for interconnection vary widely, depending on the existing circuit configuration in comparison to the desired islandable, microgrid configuration. Island mode requirements serve as a driving factor for costs, especially regarding speed and power quality during switching. Other confounding factors include the following: the distances over which power and energy must be distributed; the variability of load levels; and the needs for sophisticated dynamic energy management.

We expect costs of interconnecting two (or more) microgrids will range from $15/m and $2,796/m for wiring, plus $480/kW to $1,350/kW, based on the required equipment capacity. Key critical considerations include the following: whether wiring will be buried or above ground; challenges related to right-of-way issues; power quality and speed required when switching between interconnected grids; power capability required; and the distance between interconnections. As noted above, an on-site analysis would be required to specify an appropriate system design for each interconnection; the cost of such a study is estimated at $5,000 to $20,000 per interconnection in the microgrid.

As noted, this analysis provides an initial planning estimate for interconnection of a generic microgrid; it is not intended to replace detailed engineering analysis considering special requirements for a given site.