

DOE/OE Transmission Reliability Program

Multi-terminal HVdc

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June 2015

Washington, DC



Project Objective

- The work reported last year was a startup effort, based on recognition that

- ac lines exist
- ac networks exist
- dc lines exist
- dc networks do *not* exist. DC systems are point-to-point*
- The advantages of dc apply to networks as well as point-to-point
- The advantages of networks apply to dc as well as ac
- It just made sense to look at what one could “do” with such a thing as a dc network, assuming you could build one

	ac	dc
pt-pt	✓	✓
net	✓	



* There are now three exceptions of the ~180 that have been built

Why?

- DC is cheaper to own for high-power long distance transmission
- Networks offer much greater reliability (redundancy) than point-to-point connections
- Why are there no dc networks?
 - The economics of going from 2 terminals to 3 is not good: equipment utilization factor must suffer, or system flexibility
 - In a flexible network not all equipment is fully loaded all the time
 - There are some technical obstacles to making a dc network (breaker?)
- But with the new voltage sourced converters, the problems are most likely solvable



Project result

- We wrote a report on the technology and possible applications for a future dc networked transmission system
- The report increased “comfort level” for dc grids, and preparing the reader for what they had to offer long-term
- We showed that multi-terminal HVdc systems are both *advantageous* and *feasible*

Title: **An Introduction to High Voltage dc Networks**

Harold Kirkham, Marcelo Elizondo, Jeff Dagle

Has been disseminated via a WG of IEEE PSRC



Looking Forward

- Follow-on ideas more focused (now the case is made)
 1. Examine Economics
 1. Use factor of elements in a network will be less than 100%
 2. Advantages of dc network must be monetized
 2. Consider modelling and control questions in depth.
 1. Link to PMU applications?
 3. Consider protection in depth. This is the topic of an IEEE PES PSRC working group, and is very challenging



Deliverables

#	Milestone/Deliverable	Target Date
1	Deliver draft research plan (Letter Report) describing use cases and outlining economic challenges	9/30/2015
2	Draft Final Report summarizing results to DOE for comment	4/30/2016
3	Final Report on HVDC economic analyses	5/31/2016



Risk Factors

Economics

The risk is that we will not be able to justify the use of dc networks

But our goal is not to justify them – it is to provide an understanding of how to go about doing that

We will look at the economics of the whole system. We will include the cost of losses. We do not plan to include dynamic controls – only steady state

Harder to account for will be factors like the value of improved margins, the value of reinforcement deferments



Follow-on into FY16

Early thoughts: Protection and “special control”

Two technically challenging areas:

Protection of dc is a mix of control ideas and protection. The control ideas have to be thought through, and there is no experience on which to draw

“Special control” means linking with wide-area measurements for management of damping and Special Protection Systems

