

Feasibility Study of EHV AC Underground Cable Integration in the Future Dutch Transmission System

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PhD Thesis Factsheet

Thesis Factsheet

- Feasibility Study of EHV AC Underground Cable Integration in the Future Dutch Transmission System
- Hossein Khalilnezhad
- 1-9-2013 / 1-9-2017
- Electrical Sustainable Energy
- Dr. Marjan Popov and Prof. Lou Van der Sluis
- Financed by TenneT TSO B.V.

Thesis content

- **Motivation, background**

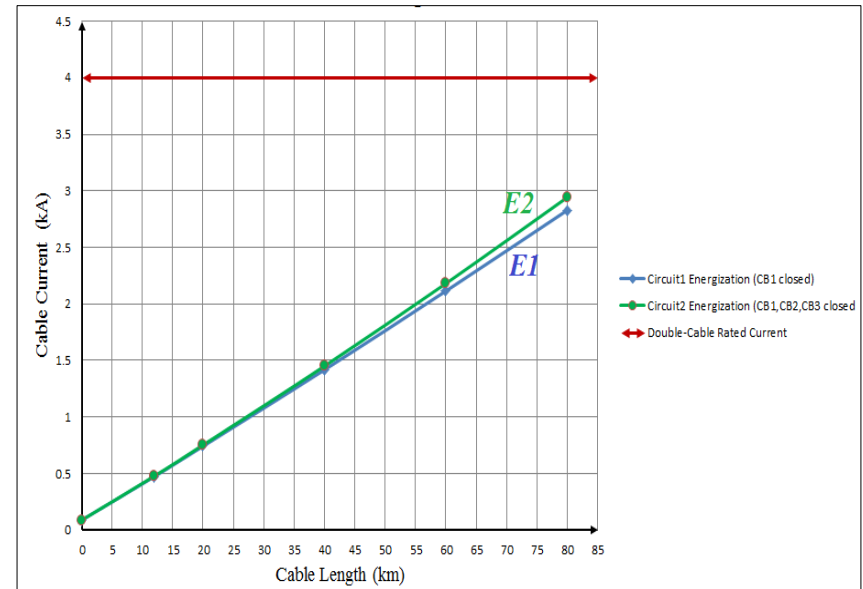
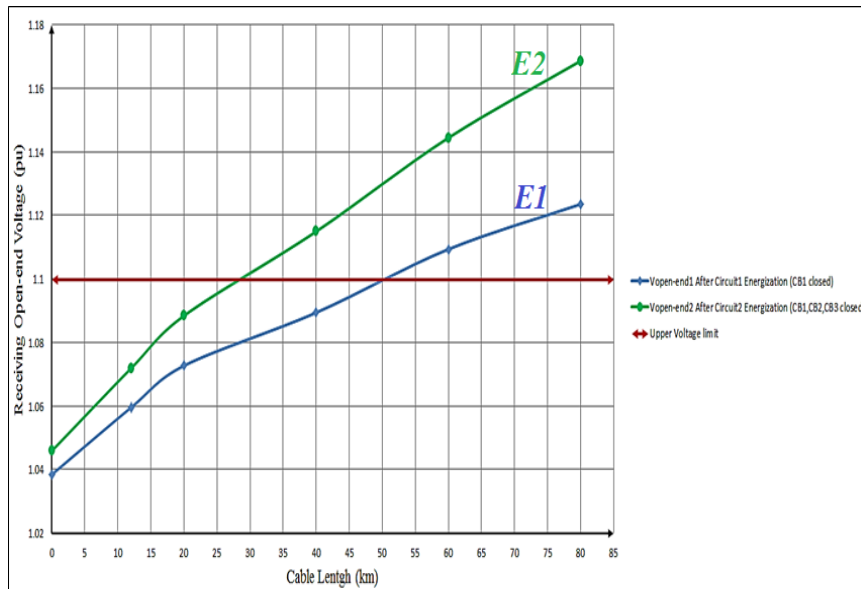
- Power transmission systems are mainly based on the OHLs
 - Well-tried technology and cheap
 - Easy repair and maintenance
- Transmission grids need to be continuously upgraded
- However, the construction of new OHLs has its own difficulties:
 - Visual effects and land occupation
 - Environmental compatibility
 - Property price decrement
 - Possible health risks of electromagnetic fields
- Public opposition as well as political pressure on TSOs
- The pressure made building of new OHLs more difficult than before
- Partial undergrounding of EHV grids can limit/remove these problems, but it is not yet a well-practiced technology

Thesis content

- **Research question**

- How the system behavior changes with large share of EHV cables?
- How the system behavior changes with increasing length of cable?
- How long is the maximum length of cable?
- What is the most limiting factor for cable length?
- What are the preconditions for future undergrounding?
- What is the best mixed-line configuration?
- What are the toolboxes for study of cable projects?

Expected results



- Parameter Y vs. cable length, like:
 - Resonance frequency vs. cable length
 - Switching overvoltage vs. cable length
- Parameter Y vs. mixed-line configuration
- Switching overvoltage vs. time

Thesis challenge

- Lack of sufficient experience from both system and component point of view
- Diversity of topics:
 - Steady state operation
 - Transients behaviour
 - Harmonics study
 - Dynamic stability
- Simulations in four software packages (PSS/E,PSCAD,PowerFactory,Matlab)
- Integration of all previous studies in one comprehensive study
- Large number of unknowns and need of sensitivity analysis
- Find **preconditions and toolboxes** required for study of any cable project
- Extreme political pressure both in the Netherlands and Germany

Methodology

- Three different kind of case study projects:
 1. Under Operation/Construction projects
The Randstad 380kV South ring and North ring
 2. Replacement projects
Existing parts of the Dutch EHV network
 3. Future projects
New grid reinforcements which are not yet part of the EHV network
- Research approach depends on the project
- Study on several projects successively

Project Plan

<i>Ph.D. Research Time Schedule</i>												
Project	WP No.	WP name	Description	Topology	Software	2014		2015		2016		2017
						Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-Sep
-	1	Literature review and data collection	Reading journal papers, progress reports, grid code documents and collection of models and data	---	---							
First project ; Krimpen-Dodewaard (Spaak)	2	Steady state operation	Load flow analysis, Compensation design (sizing and arrangement) and voltage levels	2020 Dutch model	Power-Factory							
	3	Harmonic analysis	Harmonic frequency scan and analysis	KEMA model(220 and 380 kV)	Power-Factory							
	4	Transient operation	Switching resonances (+frequency scan)	2020 Dutch model	PSCAD							
			DC offset/Zero-missing phenomenon									
			Lightning									
			Faults									
	5	Dynamic stability	Rotor angle, voltage and frequency stability	2020 Dutch model	PSS/E							
	6	Reliability	Influence of large share of cables on system reliability	Bart models/ 2020 Dutch model	PSS/E, Power-Factory, Matlab							
Randstad 380kV South and North			WP3, WP4									
Next projects and the mutual interaction of cable projects			WP2, WP3, WP4, WP5, Wp6									
-	7	Thesis	Writing final essay	---	---							
<div> <div></div> Major contribution <div></div> Minor contribution <div></div> MSc graduation projects/Internship </div>												