MEMORANDUM

SUBJECT Harmonic impedance loci at EHV-grid connection point for the offshore areas HKN and HKW-alpha

REPORT ■

DECISION ☐

1. Introduction

This memo specifies the root loci of the calculated harmonic impedances at the 380 kV substation Beverwijk, the connection point to the onshore grid. These root loci can be used by the wind farm developers to verify their compliance with the harmonic requirements.

2. Starting points

The calculations are performed based on the following starting conditions:
- The calculations are performed for the offshore wind farm connections to the platforms 'Hollandse Kust Noord'(HKN). This platform will be connected to the 380 kV substation Beverwijk.
- The modelled 380 kV onshore grid for the year 2025 is used.
- The harmonic impedance is calculated at the 380 kV busbar at the substation Beverwijk, but with the platform disconnected.
- The harmonic impedance is calculated up to the 50_{th} harmonic (2500 Hz). The calculated harmonic impedances are divided into five harmonic order sets (h = 1-13, 13-18, 18-33, 33-38 and 38-50). For each set the root locus is defined, including all relevant 'N-0', 'N-1' and 'N-2' onshore grid configurations.

3. Results

For each onshore grid situation and harmonic order set the outline of the area of the grid impedances is defined. For each area the following general layout of the outline, see figure 1, is valid, specified by the values φ_{min}, φ_{max}, R_{min}, R_{max}, X_{min}, and X_{max} as presented in table 1.
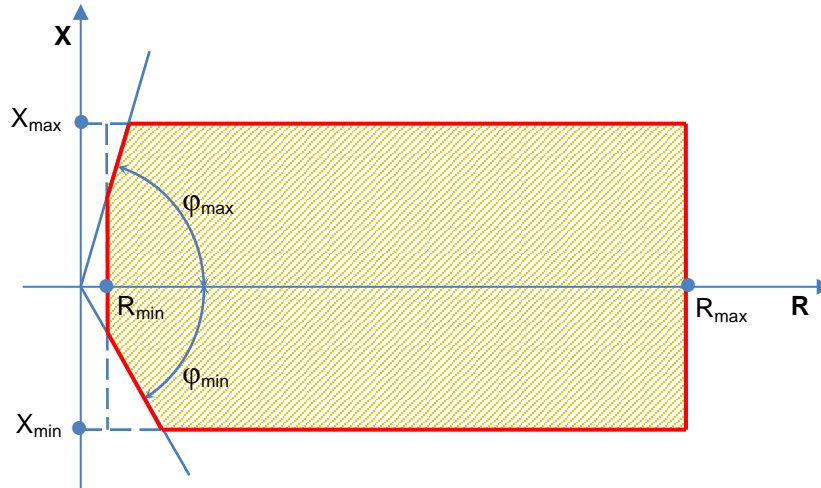

figure 1: General layout outline (in red) of the harmonic impedance profile:

table 1: Defined values for the impedance profiles

harmonic order	defined values					
	φ_min (º)	φ_max (º)	R_min (Ω)	R_max (Ω)	X_min (Ω)	X_max (Ω)
$1 \le h < 13$	-61	82	1	142	-64	74
$13 \le h < 18$	-84	83	2	422	-224	226
$18 \le h < 33$	-86	89	1	337	-164	274
$33 \le h < 38$	-71	86	4	596	-362	282
$38 \le h < 51$	-87	89	2	419	-350	448

Remark: the indicated area in figure 1 shall normally be defined by all parameters (φ_{min}, φ_{max}, R_{min}, R_{max}, X_{min} and X_{max}), but in some cases the angle φ_{max} or φ_{min} does not cross the outline of the underlying R-X rectangle and may be ignored.