Base Load Power Hub (BLPH)

Electrical System Study Report - Transient In-Rush

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

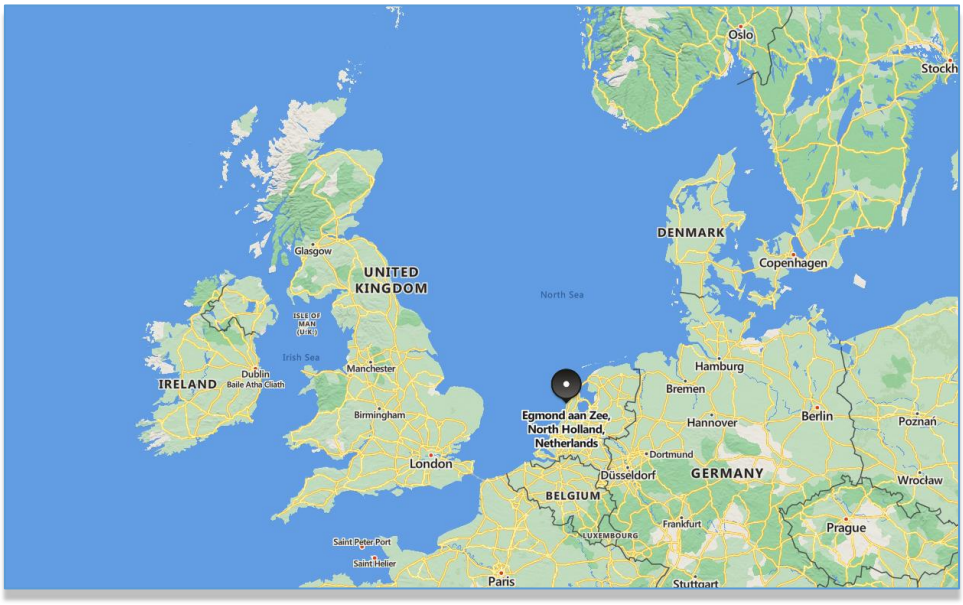


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

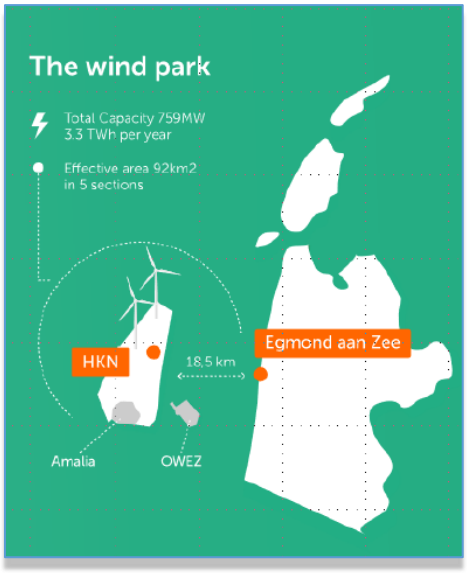


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

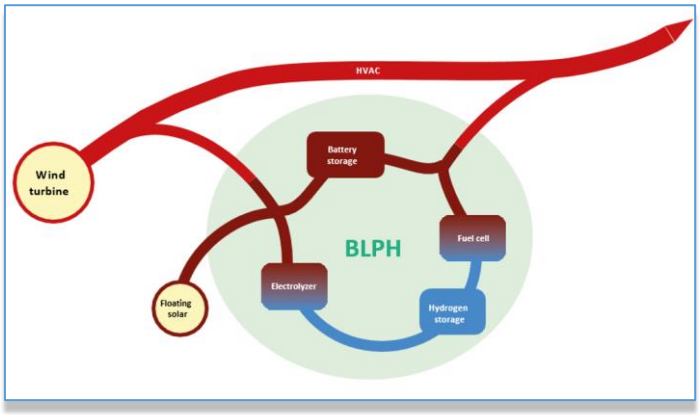


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

The scope of this document is to present the voltage dip due to the energization of transformer TR-100AD1 from the grid (windfarm), as well as the voltage dip due to the energization of transformer TR-200DE1 from the grid (windfarm).

No transformer energization has been considered during Island condition, since when the BLPH transitions to Emergency (Island) mode, it is assumed that the transformers were operating and were energized prior to the disconnection of the windfarm; the BESS system is not expected to energise any transformer.

2.1 REFERENCES

Doc. No.	Description
123A90-DDL-EL-LIS-20148 Rev 00	Electrical Power and Control Cable Schedule
123A90-DDL-EL-LIS-20016 Rev. 2	Electrical Load List & Balance (CCS Mode 'Import)
123A90-PML-PM-TQ-00033	Technical Query – Electrical data of WTG-57
123A90-DDL-EL-RE-20170 Rev. 1	Electrical System Study Report – Load Flow
123A90-DDL-EL-RE-20171 Rev. 1	Electrical System Study Report – Short circuit
123A90-DDL-EL-DG-20158 Rev. 1	Overall Single Line Diagram
144671-TKF-IAC-INS-SPE-0001	Technical specification – 66 kV Al 3X400 CONF143350 specification (incl. Drain wire)
IEC-60092-352 (2005-09)	Electrical installations in ships – Part 352: Choice and installation of electrical cables
2XS(FL)2Y HDPE High Voltage 36/60 (72.5) kV Cable	Cable catalogue for HV cable
123A90-PML-PM-TQ-00033_REPLY	Technical Query N. 33
123A90-DDL-EL-LIS-20143 Rev. 1	Electrical Load List and Balance (CCS MODE 3 -HOT STANDBY)
123A90-DDL-EL-LIS-20144 Rev. 1	Electrical Load List and Balance (CCS MODE 2 -EXPORT)
123A90-DDL-EL-LIS-20145_ATT1	CCS MODE 4: COLD STANDBY
123A90-DDL-EL-LIS-20146_ATT1	CCS MODE 5 : EMERGENCY MODE (Island)
123A90-DDL-EL-LIS-20147_ATT1	CCS MODE 6: POWER OUT (Blackout)
123A90-DDL-EL-LIS-20016_ATT1	CCS MODE 1: Import Charging
1723001697-EL-TDS-00005	Transformers DataSheet

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

Al	Aluminium
AN	Air Natural
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
Cu	Copper
COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
HV	High Voltage
KNAN	Non mineral oil natural Air Natural
LV	Low Voltage
MV	Medium Voltage
N/A	Not Applicable
NER	Neutral Earthing Resistor
OCTC	Off Circuit Tap Changer
OLTC	On Load Tap Changer
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
U_k	Short-circuit impedance
WTG	Wind Turbine Generator
XLPE	Cross-linked PolyEthylene

Table 2 - Definitions and Abbreviations

3 DESIGN BASIS

This section presents the details of all the input data, as well as assumptions used for the system studies for BLPH.

3.1 SYSTEM OVERVIEW

The system studied in this report is based on the single line diagram, 123A90-DDL-EL-DG-20158. The WTG-57 is the wind turbine being connected to the BLPH. It is connected to the rest of the Crosswind offshore windfarm at the end of string A at a 66 kV busbar. The BLPH is also connected to this busbar via a 66/6.9 kV transformer. At the BLPH 6.6 kV BLPH busbar the BESS, electrolyser, fuel cell and solar farm is connected. There is also a 6.6/0.42 kV transformer supplying different loads at the BLPH.

3.2 MODEL OVERVIEW

WTG-57 is connected to the Crosswind offshore windfarm, via string A. WTG-57 is at the end of this string A.

BLPH is connected to the Crosswind offshore windfarm at the common 66 kV busbar with the WTG-57.

At this 66 kV busbar, the rest of the components in the string A is modelled as the supply network. This is termed as "windfarm" in the model.

Other electrical components connected to this 66 kV busbar, 6.6 kV busbar and 400 V busbar are in accordance with the single line diagram in 123A90-DDL-EL-DG-20158, as well as datasheets of transformers.

Data provided in the single line diagram 123A90-DDL-EL-DG-20158 were used to model these transformers.

The study has been performed using ETAP (Electrical Transient Analyzer Program) Version 22.0.5.

4 DESIGN BASIS

Electrical parameters for TR-100AD1 from MF TRANSFORMATORI as per 1723001697-EL-TDS-00005 Datasheet including equipment layout footprint are listed in Table 3.

Electrical parameters	Value
Vector group	Dyn11 NER (9.96 Ω) grounding at secondary (HV) neutral
Voltage level (kV/kV)	66±8X1.25%/6.9 - OLTC
Apparent power	7 MVA, KNAN
Short circuit impedance	8% at principal tap
No load loss	6.2 kW
Load loss	34.8 kW at 75°C

Table 3: Electrical parameters for transformer TR-100AD1

Electrical parameters for TR-200DE1 from MF TRANSFORMATORI as per 1723001697-EL-TDS-00005 Datasheet including equipment layout footprint are listed in Table 4.

Electrical parameters	Value
Vector group	Dyn11 solid grounding at secondary (LV) neutral
Voltage level (kV/kV)	6.6±2X2.5%/0.42 OCTC
Apparent power	1.6 MVA, KNAN
Short circuit impedance	6% at principal tap
No load loss	1.08 kW
Load loss	12 kW at 75°C

Table 4: Electrical parameters for transformer TR-200DE1

The Magnetization curve for TR-100AD1 and TR-200DE1 are given in Table 5 and Table 6 respectively, as provided by the transformers manufacturer MF TRANSFORMATORI.

No Load Current [%]	Inrush flux [pu]
0,04	0,50
0.06	0.70
0.11	0.90
0.15	0.95
0.21	1.00
0.37	1.05
0.81	1.10
5.20	1.20
10.90	1.30
51.00	1.50
114.00	1.60
223.00	1.70
415.00	1.80

Table 5: Magnetization Curve for TR-100AD1

No Load Current [%]	Inrush flux [pu]
0,03	0,50
0.04	0.70
0.06	0.90
0.07	0.95
0.08	1.00
0.11	1.05

0.15	1.10
0.39	1.20
4.14	1.30
6.28	1.50
10.20	1.60
17.90	1.70
33.30	1.80

Table 6: Magnetization Curve for TR-200DE1

4.1 SYSTEM STUDIES BACKGROUND

An inrush current is expected when energizing transformers because of the magnetization of the transformer's core. For weak networks, the transformer inrush current may cause a severe voltage drop in the power system. The peak inrush current depends on the transformer's saturation characteristics and the core's remanent flux before the breaker closes.

The first simulation case is to energize the transformer TR-100AD1 by the windfarm by closing the 66 kV circuit breaker on the primary side while the 6.6 kV circuit breaker on the secondary side is open.

The second simulation energises the transformer TR-200DE1 a by 6.6 kV network by closing the 6.6 kV circuit breaker on the primary side while the 0.4 kV circuit breaker on the secondary side is open.

The worst-case inrush current of a transformer occurs when the energy source is at the voltage zero crossing of one of the phases and with an initial (residual) flux of 0.7 pu at that phase.

4.2 BASIS OF CALCULATION

The dynamic simulation model used for the transient inrush study is made with Etap 22.5.0.

Figure 4 shows the circuit breakers involved in energizing transformer TR-100AD1 from the windfarm.

Figure 5 shows the latched fused contactor and circuit breaker involved in energizing transformer TR-200DE1 from 6.6 kV network.

In both figures transformer are highlighted in blue, while the circuit breaker to be closed to energize each transformer is highlighted in green. Red mark, instead, identifies the breaker on the secondary side of the transformer that shall remain open until the transformer is not energized.

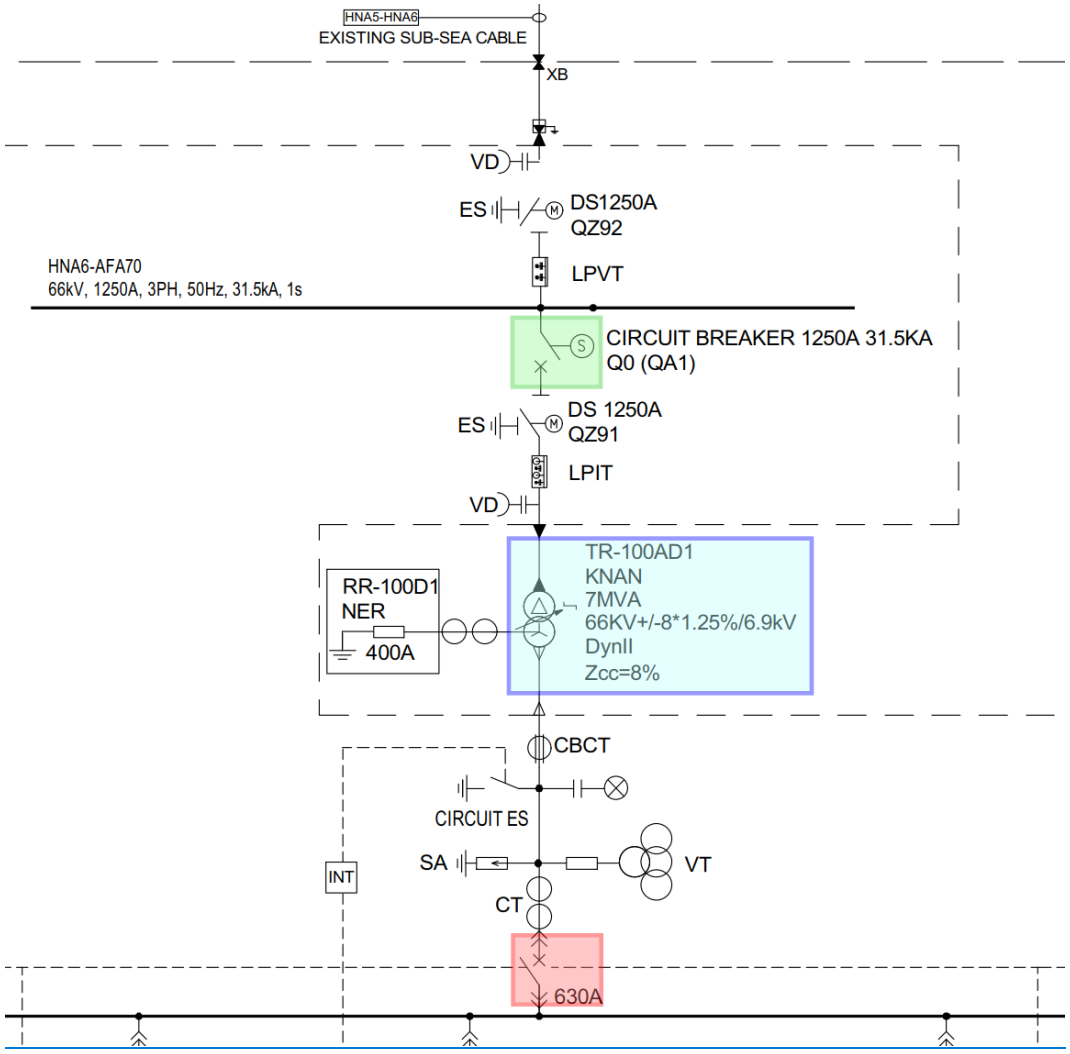


Figure 4: Circuit breakers involved in energizing transformer TR-100AD1 from windfarm

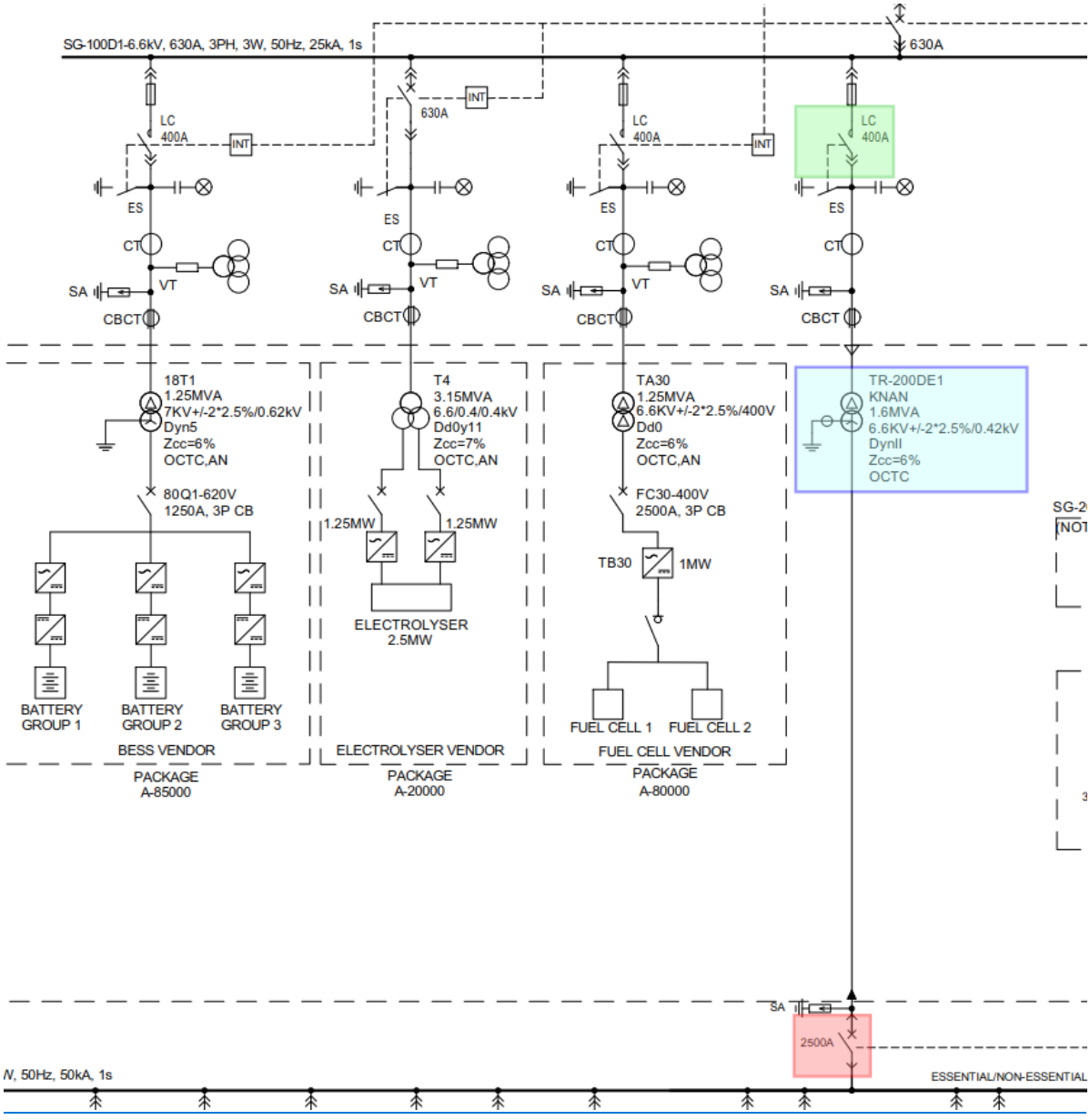


Figure 5: Latched fused contactors involved in energizing transformer TR-200DE1 from 6.6 kV network

5 TRANSIENT STABILITY STUDY – MAGNETIZATION ANALYSIS

The magnetization study aims to calculate the voltage profile during the energization of the main transformers and check that the 66kV network can support transformer energization.

5.1 ETAP STUDY ASSUMPTIONS

calculation method: Adaptive Newton Raphson.

Apply XFMR No Load Loss & Inrush

initial voltage conditions: bus initial voltages.

update: initial bus voltages, transformers LTCs, cable load amp.

adjustments: transformer impedance tolerance: +/-10% - IEC Tolerance.

5.2 CASE 1: TR-100AD1 MAGNETIZATION

- Load Diversity Factor: None.
- Power Grid 66kV in service, with minimum short circuit power.
- resistance temperature correction: Global 90°C.
- A-85000 Bess Package out of service.
- A-20000 Electrolyser Package out of service.
- A-80000 Fuel Cell Package out of service
- PV Solar Package out of service
- 66 kV GIS circuit breaker Q0 closed
- SG-100D1 incomer breaker open

5.3 CASE 2: TR-200DE1 MAGNETIZATION

- Load Diversity Factor: None.
- Power Grid 66kV in service, with minimum short circuit power.
- resistance temperature correction: Global 90°C.
- A-85000 Bess Package out of service.
- A-20000 Electrolyser Package out of service.
- A-80000 Fuel Cell Package out of service
- PV Solar Package out of service

- 66 kV GIS circuit breaker Q0 closed (TR-100AD1 already energized)
- SG-100D1 incomer breaker closed
- SG-200N1incomer breaker open

6 SIMULATION RESULTS

6.1 ENERGIZING TR-100AD1 FROM THE WINDFARM

The TR-100AD1 transformer is energized by the windfarm at 66 kV while isolated from the rest of the BLPH. The circuit breaker Q0 (QA1) is closed at zero crossing of one of the phase voltages (phase A) after t =0.1 second, which causes a worst-case inrush current.

Non-zero residual flux is considered equal to 59% according to vendor curve.

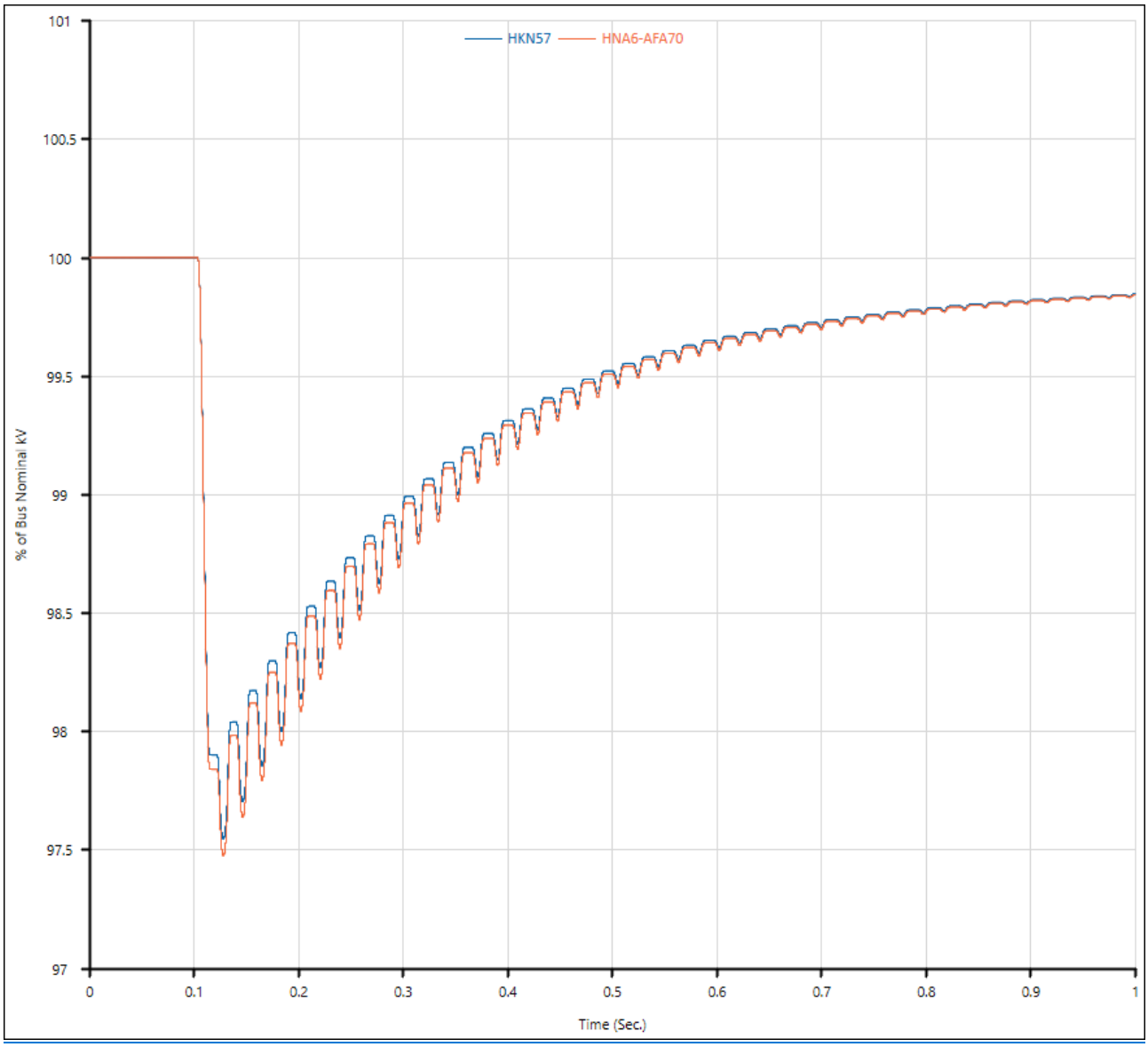


Figure 6: Voltage Profile on HKN57 and HNA6-AFA70 switchgears

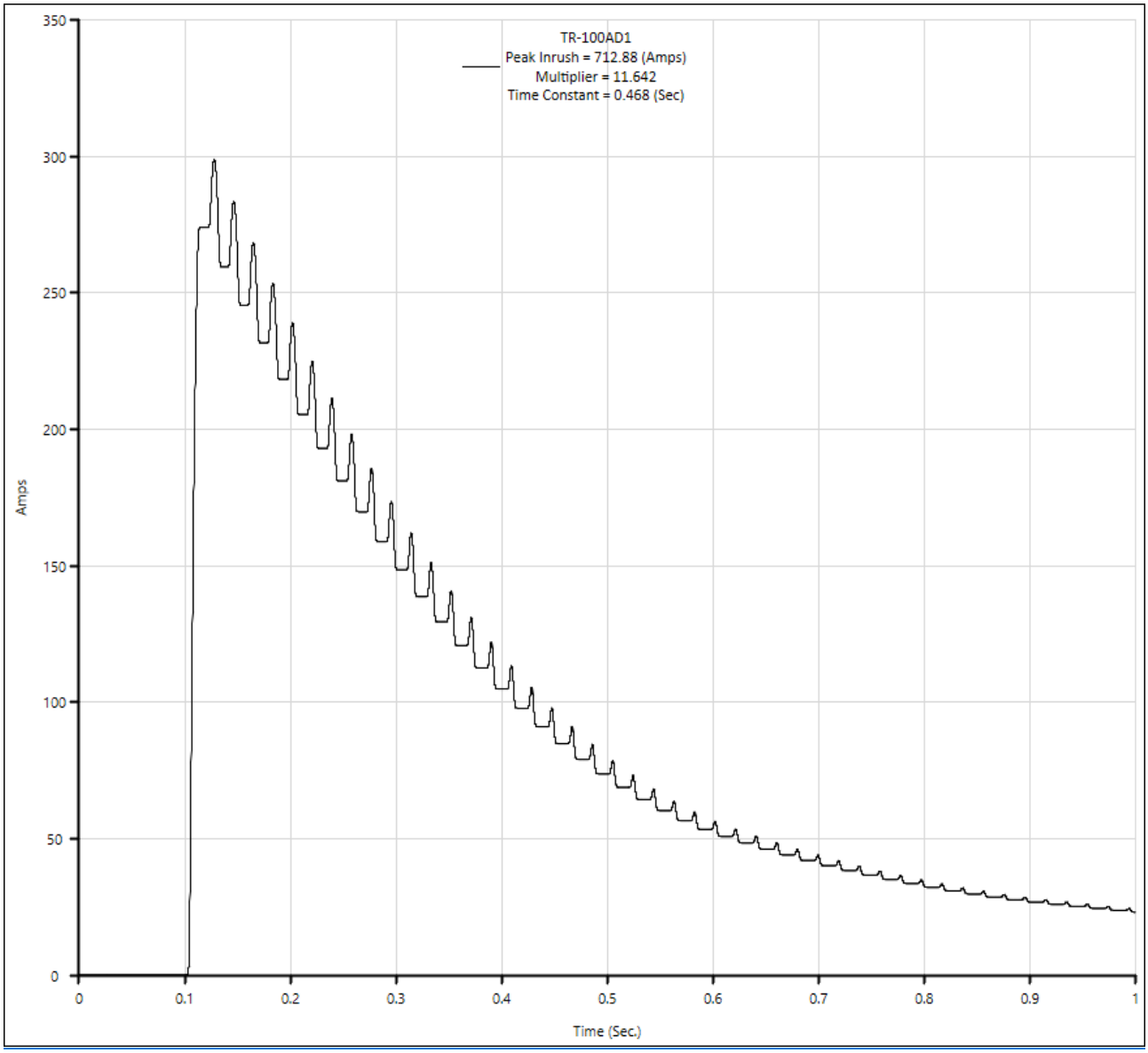


Figure 7: RMS Current at 66 kV side of TR-100AD1

6.2 ENERGIZING TR-200DE1 FROM 6.6 KV NETWORK

The TR-200DE1 transformer is energized by the windfarm at 6.6 kV via TR-100AD1. The latched fused contactor is closed at zero crossing of one of the phase voltages (phase A) after t =0.1 second, which causes a worst-case inrush current.

Non-zero residual flux is equal to 91% according to vendor curve.

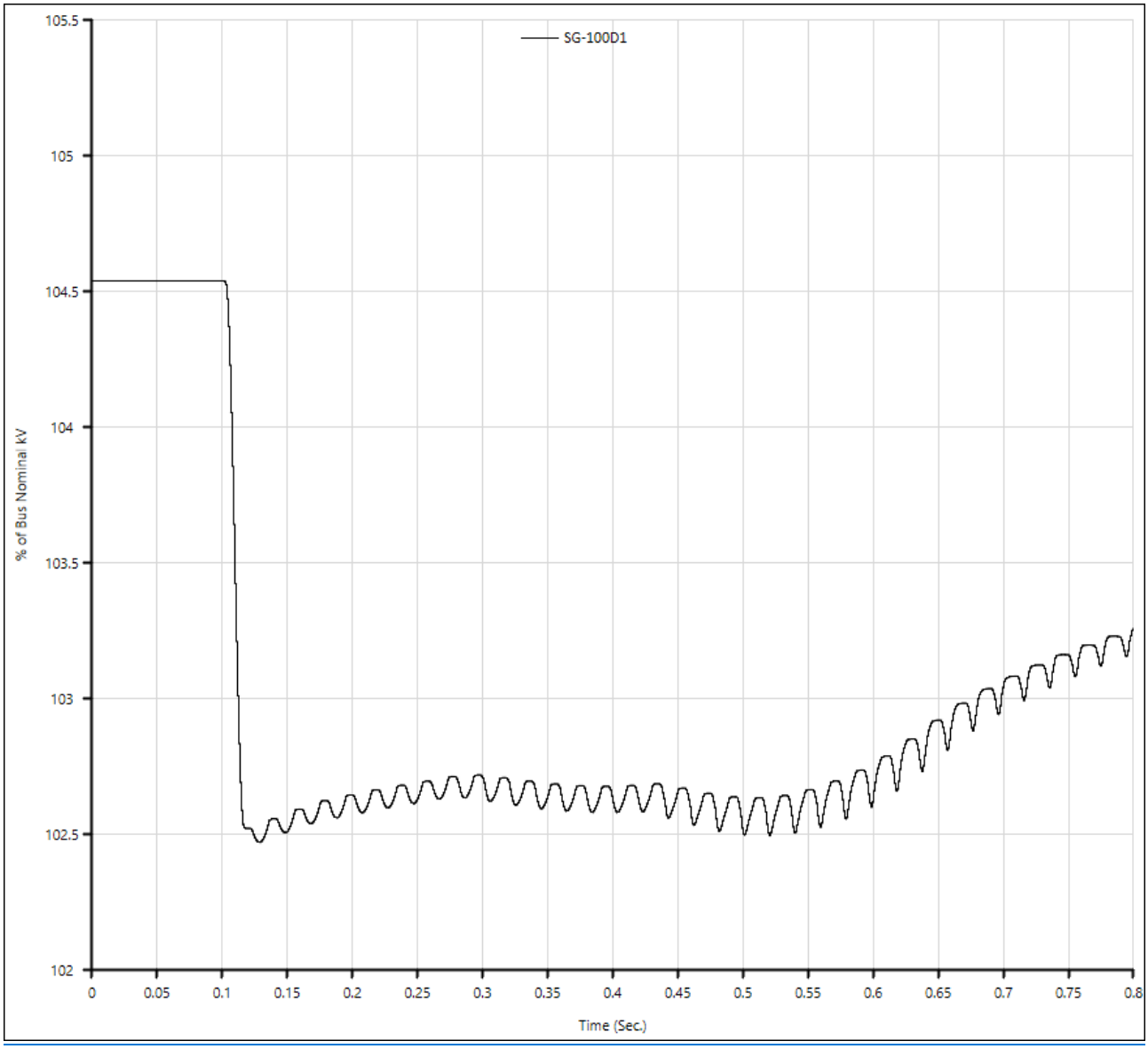


Figure 8: Voltage Profile on SG-100D1

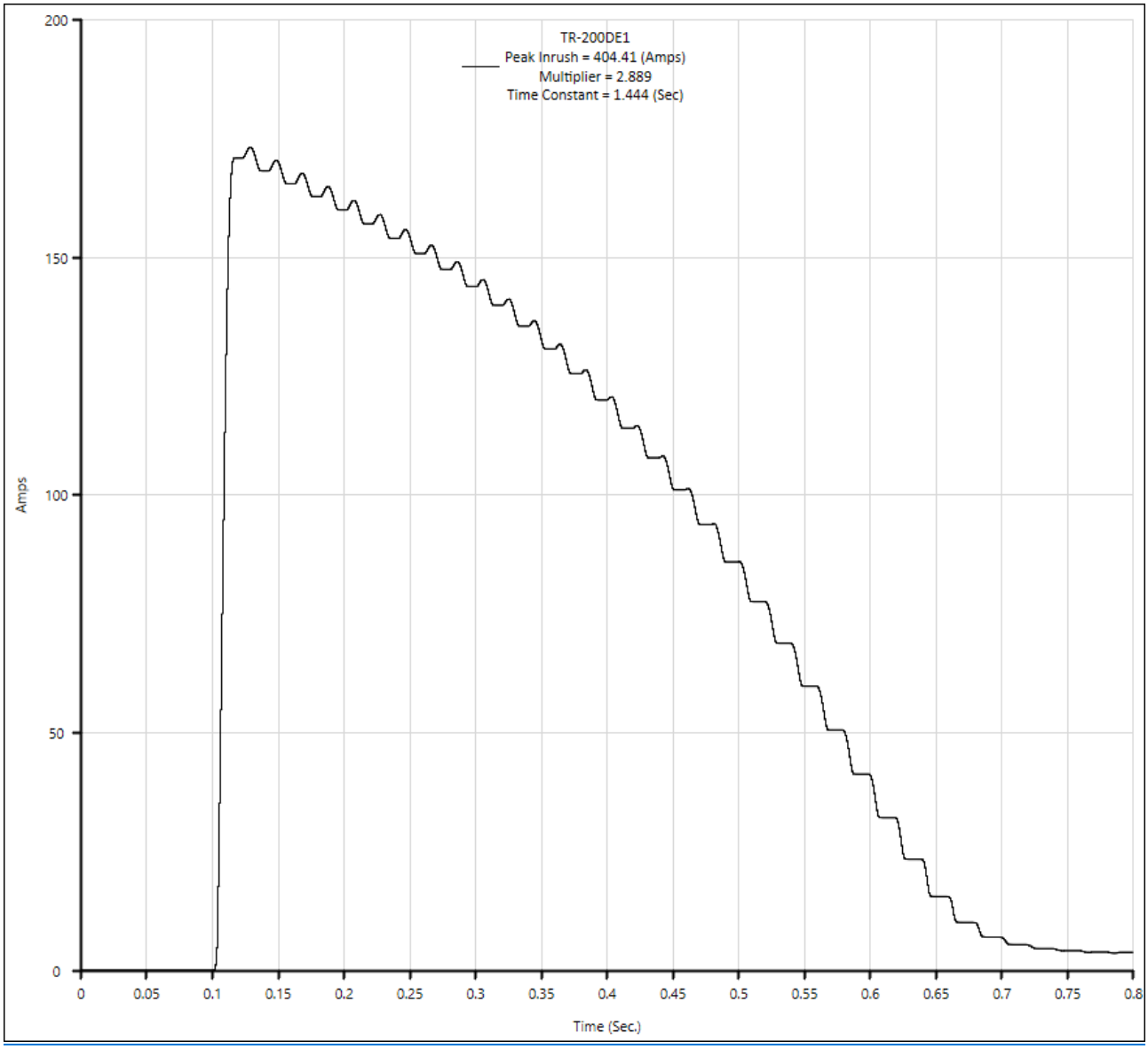


Figure 9: RMS Current at 6.6 kV side of TR-200DE1

7 CONCLUSION

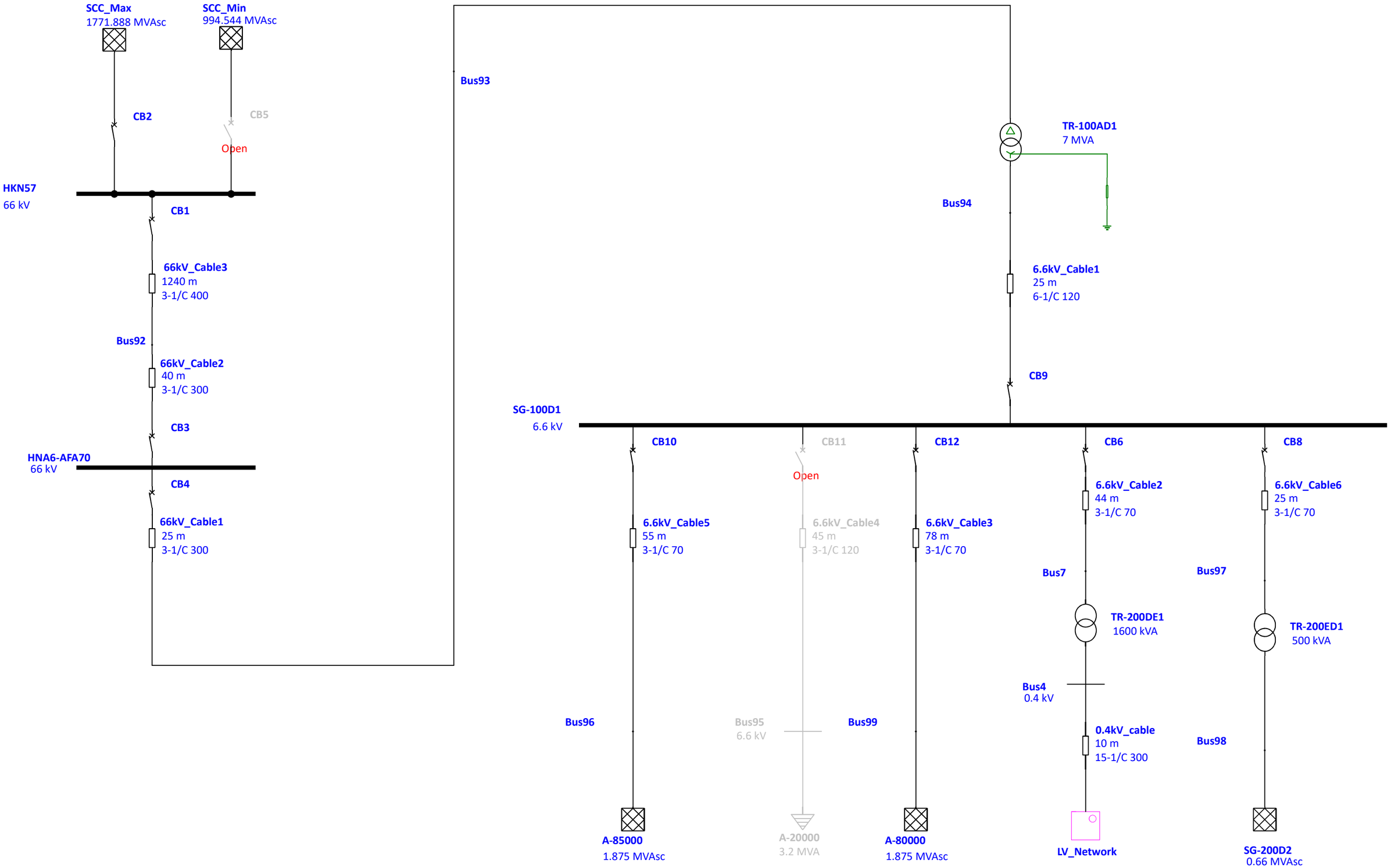
This study presents the effect of transient inrush when energizing 7 MVA transformer (TR-100AD1) from the windfarm, as well as the effect of transient inrush when energizing 1.6 MVA transformer (TR-200DE1) from the windfarm via TR-100AD1.

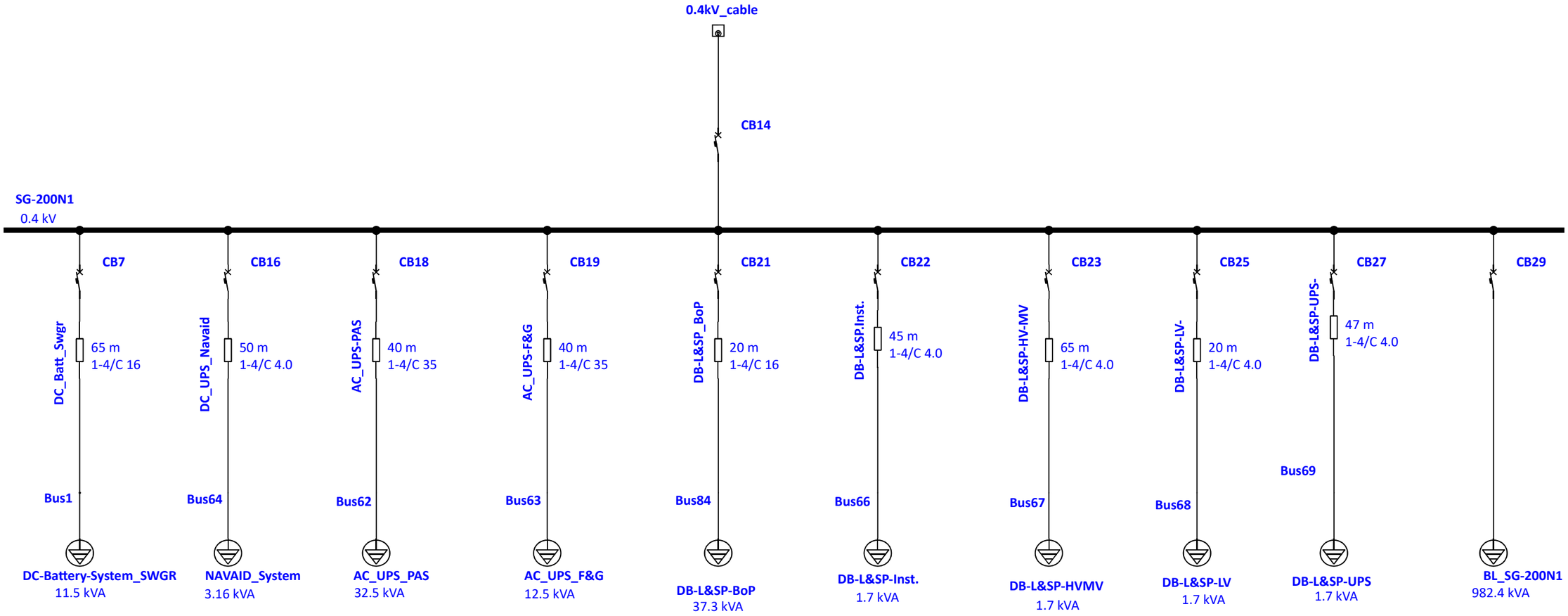
As seen from the simulation results, the voltage drop when energizing TR-100AD1 from windfarm is approximately 2.5% on the 66 kV system while the voltage drop when energizing TR-200DE1 from windfarm via TR-100AD1 is approximately 2.0% on the 6.6 kV system.

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ATTACHMENTS

Attachment 1 Electrical system model in Etap


SCC_Max
1771.888 MVAsc
SCC_Min
994.544 MVAsc
CB2
CB5
Open
HKN57
66 kV
CB1
66kV_Cable3
1240 m
3-1/C 400
Bus92
66kV_Cable2
40 m
3-1/C 300
CB3
HNA6-AFA70
66 kV
CB4
66kV_Cable1
25 m
3-1/C 300
Bus93
TR-100AD1
7 MVA
Bus94
6.6kV_Cable1
25 m
6-1/C 120
CB9
SG-100D1
6.6 kV
CB10
CB11
Open
CB12
CB6
CB8
6.6kV_Cable5
55 m
3-1/C 70
6.6kV_Cable4
45 m
3-1/C 120
6.6kV_Cable3
78 m
3-1/C 70
6.6kV_Cable2
44 m
3-1/C 70
6.6kV_Cable6
25 m
3-1/C 70
Bus7
Bus97
TR-200DE1
1600 kVA
TR-200ED1
500 kVA
Bus4
0.4 kV
Bus96
Bus95
6.6 kV
Bus99
0.4kV_cable
10 m
15-1/C 300
Bus98
A-85000
1.875 MVAsc
A-20000
3.2 MVA
A-80000
1.875 MVAsc
LV_Network
SG-200D2
0.66 MVAsc


0.4kV_cable
CB14
SG-200N1
0.4 kV
CB7
CB16
CB18
CB19
CB21
CB22
CB23
CB25
CB27
CB29
DC_Batt_Swgr
65 m
1-4/C 16
DC_UPS_Navaid
50 m
1-4/C 4.0
AC_UPS-PAS
40 m
1-4/C 35
AC_UPS-F&G
40 m
1-4/C 35
DB-L&SP_BoP
20 m
1-4/C 16
DB-L&SP.Inst.
45 m
1-4/C 4.0
DB-L&SP-HV-MV
65 m
1-4/C 4.0
DB-L&SP-LV-
20 m
1-4/C 4.0
DB-L&SP-UPS-
47 m
1-4/C 4.0
Bus1
Bus64
Bus62
Bus63
Bus84
Bus66
Bus67
Bus68
Bus69
DC-Battery-System_SWGR
11.5 kVA
NAVAID_System
3.16 kVA
AC_UPS_PAS
32.5 kVA
AC_UPS_F&G
12.5 kVA
DB-L&SP-BoP
37.3 kVA
DB-L&SP-Inst.
1.7 kVA
DB-L&SP-HVMV
1.7 kVA
DB-L&SP-LV
1.7 kVA
DB-L&SP-UPS
1.7 kVA
BL_SG-200N1
982.4 kVA

Attachment 2 Etap Report TS Case 1

Electrical Transient Analyzer Program

Transient Stability Analysis

Initial Loading Category (5): CCS_Mode1_Import_Charging

Initial Generation Category (5): CCS_Mode1_Import_Charging

Load Diversity Factor: None

	Swing	V-Control	Load	Total
Number of Buses:	1	0	5	6

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	SPDT	Total
Number of Branches:	1	0	0	4	0	0	0	5

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	0	1	0	0	0	0	1

Method of the Initial LF Solution:	Adaptive Newton-Raphson
Maximum Number of Iterations:	99
Solution Precision for the Initial LF:	0.0001000000
Time Increment for Integration Steps (Δt):	0.00010
Time Increment for Plots:	1 times Δt
System Frequency:	50.00 Hz

Frequency Dependent Models for Machines and Network are Not Used

Unit System:	Metric
Data Filename:	BLPH-LV-SCstudy
Output Filename:	Z:\Studies\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\TS_Case1.TS1S

Adjustments

Tolerance	Apply Adjustments	Individual /Global	Percent
Transformer Impedance:	Yes	Global	10.0
Reactor Impedance:	No		
Overload Heater Resistance:	No		
Transmission Line Length:	No		
Cable / Busway Length:	No		

Temperature Correction	Apply Adjustments	Individual /Global	Degree C
Transmission Line Resistance:	Yes	Global	20
Cable / Busway Resistance:	Yes	Global	20

Bus Input Data

Bus			Initial Voltage		Load							
					Constant kVA		Constant Z		Constant I		Generic	
ID	kV	Sub-sys	% Mag.	Ang.	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
Bus92	66.000	2	100.0	0.0								
Bus93	66.000	2	100.0	0.0								
Bus94	6.900	2	95.5	-1.8								
HKN57	66.000	2	100.0	0.0								
HNA6-AFA70	66.000	2	100.0	0.0								
SG-100D1	6.600	2	99.8	-1.8								
Total Number of Buses: 6					0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Dynamically modeled motor loads are not included in the bus motor load. See machine and motor pages for detail.

Generation Bus				Voltage		Generation			Mvar Limits	
ID	kV	Type	Sub-sys	% Mag.	Angle	MW	Mvar	% PF	Max	Min
HKN57	66.000	Swing	2	100.0	0.0					
						0.000	0.000			

Line/Cable/Busway Input Data

Line/Cable/Busway							ohms or siemens per 1000 m per Conductor (Cable) or per Phase (Line/Busway)					
			Length									
ID	Library	Size	Adj. (m)	% Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
6.6kV_Cable1	6.6NCUN1	120	25.0	0.0	2	20	0.153720	0.113000	0.0001400	0.415670	0.050600	0.0001400
66kV_Cable1	66NALS1	300	25.0	0.0	1	20	0.060914	0.120000	0.0000644	0.646877	0.067000	0.0000644
66kV_Cable2	66NALS1	300	40.0	0.0	1	20	0.060914	0.120000	0.0000644	0.646877	0.067000	0.0000644
66kV_Cable3	66NALS1	400	1240.0	0.0	1	20	0.079398	0.098700	0.0000911	0.275788	0.542900	0.0000911

Line / Cable / Busway resistances are listed at the specified temperatures.

2-Winding Transformer Input Data

Transformer	Rating					Z Variation			% Tap Setting		Adjusted	Phase Shift	
ID	MVA	Prim. kV	Sec. kV	% Z	X/R	+ 5%	- 5%	% Tol.	Prim.	Sec.	% Z	Type	Angle
TR-100AD1	7.000	66.000	6.900	8.00	16.06	0	0	10.0	0	0	8.8000	Dyn	0.000

2-Winding Transformer Grounding Input Data

Transformer	Rating			Grounding								
				Conn.	Primary				Secondary			
ID	MVA	Prim. kV	Sec. kV	Type	Type	kV	Amp	ohm	Type	kV	Amp	ohm
TR-100AD1	7.000	66.000	6.900	D/Y					Resistor		400.0	9.95958

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVA Base			
ID	Type	From Bus	To Bus	R	X	Z	Y
TR-100AD1	2W XFMR	Bus93	Bus94				
6.6kV_Cable1	Cable	Bus94	SG-100D1	0.40	0.30	0.50	0.0003333
66kV_Cable1	Cable	HNA6-AFA70	Bus93	0.00	0.01	0.01	0.0070134
66kV_Cable2	Cable	Bus92	HNA6-AFA70	0.01	0.01	0.01	0.0112215
66kV_Cable3	Cable	HKN57	Bus92	0.23	0.28	0.36	0.4921036

Branch Connections
Zero Sequence Impedance

CKT/Branch		Connected Bus ID		% Impedance, Zero Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R0	X0	Z0	Y0
TR-100AD1	2W XFMR	Bus93	Bus94				
6.6kV_Cable1	Cable	Bus94	SG-100D1				0.0003333
66kV_Cable1	Cable	HNA6-AFA70	Bus93				0.0070134
66kV_Cable2	Cable	Bus92	HNA6-AFA70				0.0112215
66kV_Cable3	Cable	HKN57	Bus92				0.4921036

Synchronous Machine Parameters

Machine			Rating		Positive Sequence Impedance (%)								Zero Seq. Z (%)		
ID	Type	Model	MVA	kV	Ra	Xd"	Xd'	Xd	Xq"	Xq'	Xq	Xl	X/R	R0	X0
SCC_Min	Power Grid	N/A	994.544	66.000	9.95		99.50							21.32	213.22

Machine	Connected Bus	Time Constants (Sec.)				H(Sec.), D(MWpu/Hz) & Saturati					Generator or Loading		Grounding		
ID	ID	Tdo"	Tdo'	Tqo"	Tqo'	H	%D	S100	S120	Sbreak	MW	Mvar	Conn.	Type	Amp

Machine		Generator/Motor			Coupling			Prime Mover/Load			Equivalent Total		
ID	Type	RPM	WR²	H	RPM	WR²	H	RPM	WR²	H	RPM	WR²	H

WR²: kg-m² H: MW-Sec/MVA

Machine		Shaft Torsion			
ID	Type	D1	D2	K1	K2

D1, D2: MW(pu)/Speed (pu) K1, K2: MW(pu)/Radiant

LOAD FLOW REPORT @ T = 0.000-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus92	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	0.000	-0.011	0.1	0.0	
								HKN57	0.000	0.011	0.1	0.0	
* HKN57	66.000	100.000	0.0	0	0	0	0	Bus92	0.000	-0.503	4.4	0.0	
								SCC_Min	0.000	0.503	4.4	0.0	
HNA6-AFA70	66.000	100.001	0.0	0	0	0	0	Bus92	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.000	-0.503	0	0	HKN57	0.000	-0.503	4.4	0.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

LOAD FLOW REPORT @ T = 0.100-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus92	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	0.000	-0.011	0.1	0.0	
								HKN57	0.000	0.011	0.1	0.0	
HKN57	66.000	100.000	0.0	0	0	0	0	Bus92	0.000	-0.503	4.4	0.0	
								SCC_Min	0.000	0.503	4.4	0.0	
HNA6-AFA70	66.000	100.001	0.0	0	0	0	0	Bus92	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.000	-0.503	0	0	HKN57	0.000	-0.503	4.4	0.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

LOAD FLOW REPORT @ T = 1.000-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus92	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	0.006	-0.011	0.1	-47.7	
								HKN57	-0.006	0.011	0.1	-47.7	
Bus93	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	-0.006	-0.008	0.1	60.7	
								Bus94	0.006	0.008	0.1	60.7	3.750
Bus94	6.900	96.381	0.0	0	0	0	0	SG-100D1	0.000	0.000	0.0	0.0	
								Bus93	0.000	0.000	0.0	0.0	
HKN57	66.000	100.000	0.0	0	0	0	0	Bus92	0.006	-0.503	4.4	-1.2	
								SCC_Min	-0.006	0.503	4.4	-1.2	
HNA6-AFA70	66.000	100.001	0.0	0	0	0	0	Bus93	0.006	0.001	0.1	99.5	
								Bus92	-0.006	-0.001	0.1	99.5	
SG-100D1	6.600	100.762	0.0	0	0	0	0	Bus94	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.006	-0.503	0	0	HKN57	0.006	-0.503	4.4	-1.2	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

Dynamic Stability

The tabulated plot data is not printed since the option of "Skip Tabulated Plots" is checked.
To print tabulated plot data go to the Transient Stability Study Case Editor and in the Info Page uncheck the "Skip Tabulated Plots" option.

System Islanding Index

Time (Sec.)	Element ID	Type	Zone No.
0.000	Bus92	Bus	1
0.000	HKN57	Bus	1
0.000	HNA6-AFA70	Bus	1
0.000	SCC_Min	Power Grid (Ref.)	1
0.100	Bus92	Bus	1
0.100	Bus93	Bus	1
0.100	Bus94	Bus	1
0.100	HKN57	Bus	1
0.100	HNA6-AFA70	Bus	1
0.100	SCC_Min	Power Grid (Ref.)	1
0.100	SG-100D1	Bus	1

Action Summary

Event ID	Time (Sec.)	Device Type	Device ID	Action
Inrush	0.100	Protective Device	CB4	Close

Attachment 3 Etap Report TS Case 2

Electrical Transient Analyzer Program

Transient Stability Analysis

Initial Loading Category (5): CCS_Mode1_Import_Charging

Initial Generation Category (5): CCS_Mode1_Import_Charging

Load Diversity Factor: None

	Swing	V-Control	Load	Total
Number of Buses:	1	0	8	9

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	SPDT	Total
Number of Branches:	2	0	0	6	0	0	0	8

	Synchronous Generator	Power Grid	Synchronous Motor	Induction Machines	Lumped Load	Inverter	Total
Number of Machines:	0	1	0	0	0	0	1

Method of the Initial LF Solution:	Adaptive Newton-Raphson
Maximum Number of Iterations:	99
Solution Precision for the Initial LF:	0.0001000000
Time Increment for Integration Steps (Δt):	0.00001
Time Increment for Plots:	1 times Δt
System Frequency:	50.00 Hz

Frequency Dependent Models for Machines and Network are Not Used

Unit System:	Metric
Data Filename:	BLPH-LV-SCstudy
Output Filename:	Z:\Studies\0351-0400\0396S_Crosswind\ETAP_15-Mar-2024\TS_Case2.TS1S

Adjustments

Tolerance	Apply Adjustments	Individual /Global	Percent
Transformer Impedance:	Yes	Individual	
Reactor Impedance:	No		
Overload Heater Resistance:	No		
Transmission Line Length:	No		
Cable / Busway Length:	No		

Temperature Correction	Apply Adjustments	Individual /Global	Degree C
Transmission Line Resistance:	Yes	Global	20
Cable / Busway Resistance:	Yes	Global	20

Bus Input Data

Bus			Initial Voltage		Load							
					Constant kVA		Constant Z		Constant I		Generic	
ID	kV	Sub-sys	% Mag.	Ang.	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
Bus4	0.400	2	99.7	-3.7								
Bus7	6.600	2	99.8	-1.8								
Bus92	66.000	2	100.0	0.0								
Bus93	66.000	2	100.0	0.0								
Bus94	6.900	2	95.5	-1.8								
HKN57	66.000	2	100.0	0.0								
HNA6-AFA70	66.000	2	100.0	0.0								
SG-100D1	6.600	2	99.8	-1.8								
SG-200N1	0.400	2	99.5	-3.7								
Total Number of Buses: 9					0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Dynamically modeled motor loads are not included in the bus motor load. See machine and motor pages for detail.

Generation Bus				Voltage		Generation			Mvar Limits	
ID	kV	Type	Sub-sys	% Mag.	Angle	MW	Mvar	% PF	Max	Min
HKN57	66.000	Swing	2	100.0	0.0					
						0.000	0.000			

Line/Cable/Busway Input Data

Line/Cable/Busway			Length			ohms or siemens per 1000 m per Conductor (Cable) or per Phase (Line/Busway)						
ID	Library	Size	Adj. (m)	% Tol.	#/Phase	T (°C)	R1	X1	Y1	R0	X0	Y0
0.4kV_cable	1.0NCUN1	300	10.0	0.0	5	20	0.062743	0.089000	0.0001854	0.099761	0.226060	0.0001854
6.6kV_Cable1	6.6NCUN1	120	25.0	0.0	2	20	0.153720	0.113000	0.0001400	0.415670	0.050600	0.0001400
6.6kV_Cable2	6.6NCUN1	70	44.0	0.0	1	20	0.268225	0.130000	0.0001100	0.533313	0.063200	
66kV_Cable1	66NALS1	300	25.0	0.0	1	20	0.060914	0.120000	0.0000644	0.646877	0.067000	0.0000644
66kV_Cable2	66NALS1	300	40.0	0.0	1	20	0.060914	0.120000	0.0000644	0.646877	0.067000	0.0000644
66kV_Cable3	66NALS1	400	1240.0	0.0	1	20	0.079398	0.098700	0.0000911	0.275788	0.542900	0.0000911

Line / Cable / Busway resistances are listed at the specified temperatures.

2-Winding Transformer Input Data

Transformer	Rating					Z Variation			% Tap Setting		Adjusted	Phase Shift	
ID	MVA	Prim. kV	Sec. kV	% Z	X/R	+ 5%	- 5%	% Tol.	Prim.	Sec.	% Z	Type	Angle
TR-100AD1	7.000	66.000	6.900	8.00	16.06	0	0	0	0	0	8.0000	Dyn	0.000
TR-200DE1	1.600	6.600	0.420	6.00	7.94	0	0	0	2.500	0	6.0000	Dyn	0.000

2-Winding Transformer Grounding Input Data

Transformer	Rating			Grounding								
				Conn.	Primary				Secondary			
ID	MVA	Prim. kV	Sec. kV	Type	Type	kV	Amp	ohm	Type	kV	Amp	ohm
TR-100AD1	7.000	66.000	6.900	D/Y					Resistor		400.0	9.95958
TR-200DE1	1.600	6.600	0.420	D/Y					Solid			

Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVA Base			
ID	Type	From Bus	To Bus	R	X	Z	Y
TR-100AD1	2W XFMR	Bus93	Bus94	7.37	118.35	118.58	
TR-200DE1	2W XFMR	Bus7	Bus4				
0.4kV_cable	Cable	Bus4	SG-200N1	6.51	9.23	11.30	0.0000018
6.6kV_Cable1	Cable	Bus94	SG-100D1	0.40	0.30	0.50	0.0003333
6.6kV_Cable2	Cable	SG-100D1	Bus7	2.48	1.20	2.75	0.0002304
66kV_Cable1	Cable	HNA6-AFA70	Bus93	0.00	0.01	0.01	0.0070134
66kV_Cable2	Cable	Bus92	HNA6-AFA70	0.01	0.01	0.01	0.0112215
66kV_Cable3	Cable	HKN57	Bus92	0.23	0.28	0.36	0.4921036

Branch Connections
Zero Sequence Impedance

CKT/Branch		Connected Bus ID		% Impedance, Zero Seq., 100 MVAb			
ID	Type	From Bus	To Bus	R0	X0	Z0	Y0
TR-100AD1	2W XFMR	Bus93	Bus94				
TR-200DE1	2W XFMR	Bus7	Bus4				
0.4kV_cable	Cable	Bus4	SG-200N1				0.0000018
6.6kV_Cable1	Cable	Bus94	SG-100D1				0.0003333
6.6kV_Cable2	Cable	SG-100D1	Bus7				
66kV_Cable1	Cable	HNA6-AFA70	Bus93				0.0070134
66kV_Cable2	Cable	Bus92	HNA6-AFA70				0.0112215
66kV_Cable3	Cable	HKN57	Bus92				0.4921036

Synchronous Machine Parameters

Machine			Rating		Positive Sequence Impedance (%)								Zero Seq. Z (%)		
ID	Type	Model	MVA	kV	Ra	Xd"	Xd'	Xd	Xq"	Xq'	Xq	Xl	X/R	R0	X0
SCC_Min	Power Grid	N/A	994.544	66.000	9.95		99.50							21.32	213.22

Machine	Connected Bus	Time Constants (Sec.)				H(Sec.), D(MWpu/Hz) & Saturati					Generator or Loading		Grounding		
ID	ID	Tdo"	Tdo'	Tqo"	Tqo'	H	%D	S100	S120	Sbreak	MW	Mvar	Conn.	Type	Amp

Machine		Generator/Motor			Coupling			Prime Mover/Load			Equivalent Total		
ID	Type	RPM	WR²	H	RPM	WR²	H	RPM	WR²	H	RPM	WR²	H

WR²: kg-m² H: MW-Sec/MVA

Machine		Shaft Torsion			
ID	Type	D1	D2	K1	K2

D1, D2: MW(pu)/Speed (pu) K1, K2: MW(pu)/Radiant

LOAD FLOW REPORT @ T = 0.000-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus92	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	0.006	-0.005	0.1	-76.3	
								HKN57	-0.006	0.005	0.1	-76.3	
Bus93	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	-0.006	-0.013	0.1	43.3	
								Bus94	0.006	0.013	0.1	43.3	
Bus94	6.900	99.993	0.0	0	0	0	0	SG-100D1	0.000	0.000	0.0	0.0	
								Bus93	0.000	0.000	0.0	0.0	
* HKN57	66.000	100.000	0.0	0	0	0	0	Bus92	0.006	-0.497	4.4	-1.3	
								SCC_Min	-0.006	0.497	4.4	-1.3	
HNA6-AFA70	66.000	100.001	0.0	0	0	0	0	Bus93	0.006	0.006	0.1	72.3	
								Bus92	-0.006	-0.006	0.1	72.3	
SG-100D1	6.600	104.538	0.0	0	0	0	0	Bus94	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.006	-0.497	0	0	HKN57	0.006	-0.497	4.4	-1.3	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

LOAD FLOW REPORT @ T = 0.100-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus92	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	0.006	-0.005	0.1	-76.3	
								HKN57	-0.006	0.005	0.1	-76.3	
Bus93	66.000	100.001	0.0	0	0	0	0	HNA6-AFA70	-0.006	-0.013	0.1	43.3	
								Bus94	0.006	0.013	0.1	43.3	
Bus94	6.900	99.993	0.0	0	0	0	0	SG-100D1	0.000	0.000	0.0	0.0	
								Bus93	0.000	0.000	0.0	0.0	
HKN57	66.000	100.000	0.0	0	0	0	0	Bus92	0.006	-0.497	4.4	-1.3	
								SCC_Min	-0.006	0.497	4.4	-1.3	
HNA6-AFA70	66.000	100.001	0.0	0	0	0	0	Bus93	0.006	0.006	0.1	72.3	
								Bus92	-0.006	-0.006	0.1	72.3	
SG-100D1	6.600	104.538	0.0	0	0	0	0	Bus94	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.006	-0.497	0	0	HKN57	0.006	-0.497	4.4	-1.3	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

LOAD FLOW REPORT @ T = 0.800-

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	% Tap
Bus4	0.400	107.054	0.0	0	0	0	0	SG-200N1	0.000	0.000	0.0	0.0	
								Bus7	0.000	0.000	0.0	0.0	
Bus7	6.600	104.509	0.0	0	0	0	0	SG-100D1	-0.001	-0.002	0.2	51.1	
								Bus4	0.001	0.002	0.2	51.1	2.500
Bus92	66.000	99.997	0.0	0	0	0	0	HNA6-AFA70	0.007	0.035	0.3	20.5	
								HKN57	-0.007	-0.035	0.3	20.5	
Bus93	66.000	99.997	0.0	0	0	0	0	HNA6-AFA70	-0.007	-0.053	0.5	13.7	
								Bus94	0.007	0.053	0.5	13.7	
Bus94	6.900	99.965	0.0	0	0	0	0	SG-100D1	0.001	0.001	0.1	64.5	
								Bus93	-0.001	-0.001	0.1	64.5	
HKN57	66.000	99.996	0.0	0	0	0	0	Bus92	0.007	-0.457	4.0	-1.6	
								SCC_Min	-0.007	0.457	4.0	-1.6	
HNA6-AFA70	66.000	99.997	0.0	0	0	0	0	Bus93	0.007	0.046	0.4	15.7	
								Bus92	-0.007	-0.046	0.4	15.7	
SG-100D1	6.600	104.509	0.0	0	0	0	0	Bus94	-0.001	-0.002	0.2	56.0	
								Bus7	0.001	0.002	0.2	56.0	
SG-200N1	0.400	107.054	0.0	0	0	0	0	Bus4	0.000	0.000	0.0	0.0	
SCC_Min	66.000	99.950	0.0	0.007	-0.457	0	0	HKN57	0.007	-0.457	4.0	-1.6	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

Dynamic Stability

The tabulated plot data is not printed since the option of "Skip Tabulated Plots" is checked.
To print tabulated plot data go to the Transient Stability Study Case Editor and in the Info Page uncheck the "Skip Tabulated Plots" option.

System Islanding Index

Time (Sec.)	Element ID	Type	Zone No.
0.000	Bus92	Bus	1
0.000	Bus93	Bus	1
0.000	Bus94	Bus	1
0.000	HKN57	Bus	1
0.000	HNA6-AFA70	Bus	1
0.000	SCC_Min	Power Grid (Ref.)	1
0.000	SG-100D1	Bus	1
0.100	Bus4	Bus	1
0.100	Bus7	Bus	1
0.100	Bus92	Bus	1
0.100	Bus93	Bus	1
0.100	Bus94	Bus	1
0.100	HKN57	Bus	1
0.100	HNA6-AFA70	Bus	1
0.100	SCC_Min	Power Grid (Ref.)	1
0.100	SG-100D1	Bus	1
0.100	SG-200N1	Bus	1

Action Summary

Event ID	Time (Sec.)	Device Type	Device ID	Action
Inrush	0.100	Protective Device	CB6	Close