TOSHIBA

HVDC Development at Toshiba and Its Outlook

2019 HVDC Operator Forum
The National HVDC Centre
Cumbernauld, Scotland
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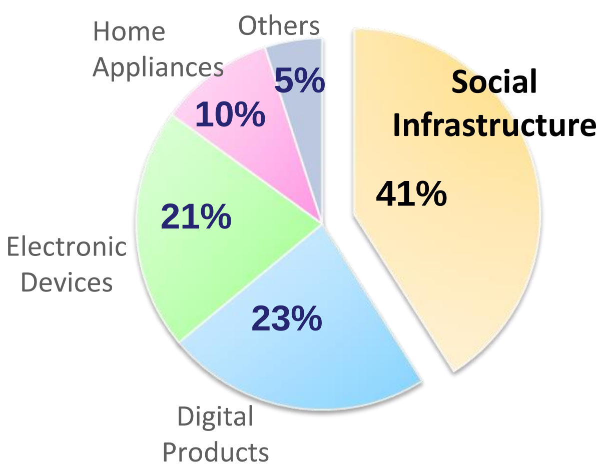
Contents

TOSHIBA
Leading Innovation

World's 10th largest electronics & electrical equipment manufacturer

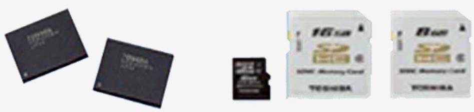
Corporate profile (As of April 1, 2015)

Established:	July 1875
Net Sales:	US$ 62 Billion
Employee:	Approx. 206,087
Subsidiaries:	554 Companies

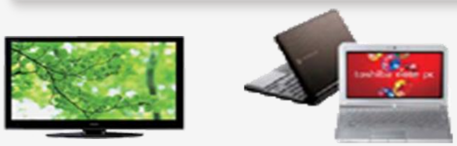


Social Infrastructure

Electronic Devices



Digital Products



Home Appliances

Provide

- Low-carbon & high-efficiency infrastructure for the electrical industry and society
- high quality systems at a competitive price

History of Toshiba HVDC Technology

1960 | 1970 | 1980 | 1990 | 2000 | 2010

R & D

Basic Developments

- Electrical machine Laboratory
  100kV Air-Cooling Valve (1969)
- Sakuma Thyristor Testing Center
  37.5MW Converter field tests (1970)
  125kV Oil-Cooling Valve (1972)

Applications

- Sakuma Frequency Converter
  125kV Water-Cooling Valve (1981)
  125kV Light-Triggered Valve (1983)

Projects

First Generation

- Shin - Shinano FC No.1 300MW, (1977); it was replaced in 2009
- Hokkaido - Honshu HVDC Link Pole - 1 300MW (1979/80)

Second Generation

- Shin - Shinano FC No.2 300MW (1992)
- Hokkaido - Honshu HVDC Link Pole - 2 300MW (1993)
- Sakuma FC 300MW (1993)

Third Generation

- Kii Channel HVDC 1400MW (2000)

Thyristor Valve

ETT
(Electrically-Triggered Thyristor)
Oil/Air Cooling

LTT
(Light-Triggered Thyristor)
Water Cooling

LTT
6 inch thyristors

Experience of HVDC System in Japan

Shin-Shinano
Frequency Converter Station

300MW – Year 1977/2009
600MW – Year 1992

DC voltage: 125kV
DC current: 2,400A
Thyristor: LTT (7.5kV-2,440A)
Cooling: Water
Insulation: Air

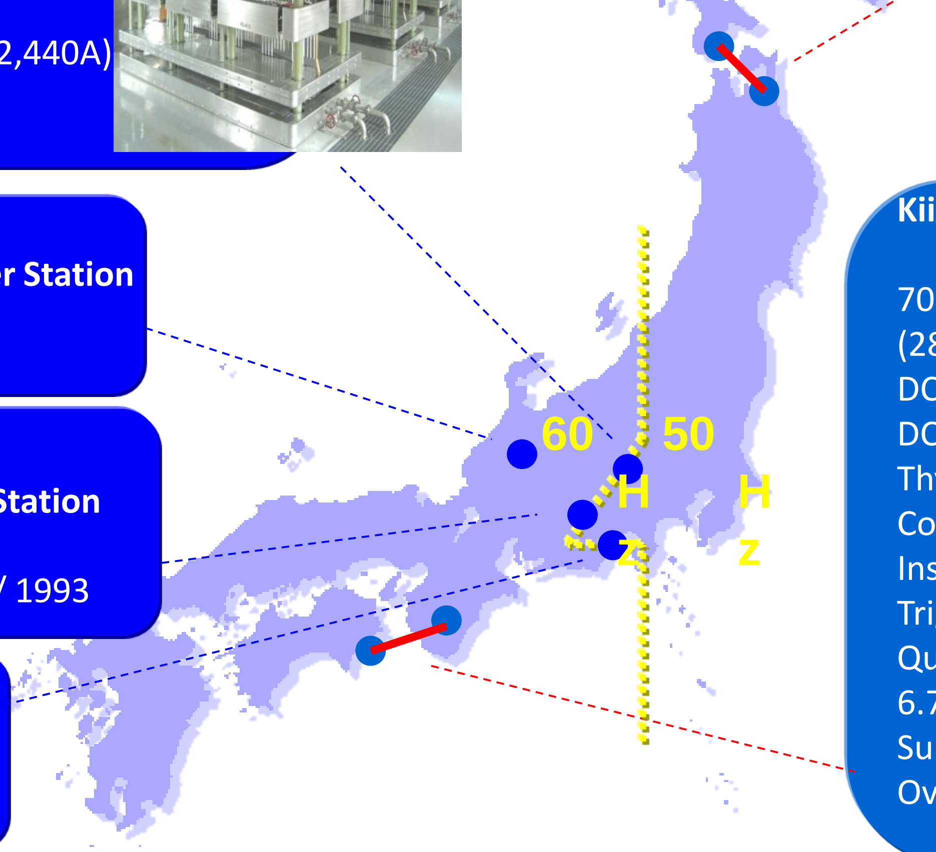
Minami-Fukumitsu
Back to Back Converter Station

300MW – Year 1999

Sakuma
Frequency Converter Station

300MW – Year 1965 / 1993

Higashi-Shimizu
Converter Station
300MW – Year 2006



Hokkaido-Honshu
DC Transmission Line

150MW – Year 1979
300MW - 1980
600MW - 1993

Kii-Channel DC Transmission Line

700MW x 2 pole - Year 2000
(2800MW in the future)
DC voltage : 250kV
DC current: 2800A
Thyristor : LTT (8kV-3500A)
Cooling : Water
Insulation: Air
Triggering: Direct Light
Quadruple valve size:
6.7W-3.7D-8.75H
Submarine cable: 50km
Overhead line: 50km

*Year: Commissioning year

Montenegro-Italy HVDC Link

- ▶ Link power grids of Italy and Montenegro across the Adriatic Sea
- ▶ Part of EU power grids integration project
- ▶ Tap into the hydro power in the Balkans and mitigate energy shortage in Italy
- ▶ Toshiba's second overseas HVDC project

PROJECT OVERVIEW:

LCC type with rapid power reversal cap

Power: 1,000MW with 20% continuous overload

DC voltage: 500kV

Length of sea cable: 415km

Commissioning in progress

Completion: End of 2019

Voltage Sourced Converter Development

TOSHIBA Leading Innovation

GTO

IEGT

1991

50Mvar STATCOM Shin-Shinano

1992

20Mvar STATCOM Teine

1997

53MW 3-Teminal FC Shin-Shinano

2004

60MW FC Tsunashima Shinkansen

2007

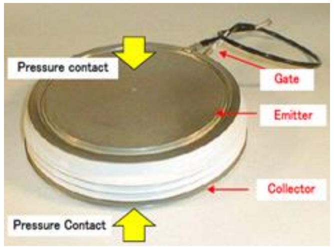
90Mvar STATCOM Electricity

2009

60MW FC Numazu Shinkansen

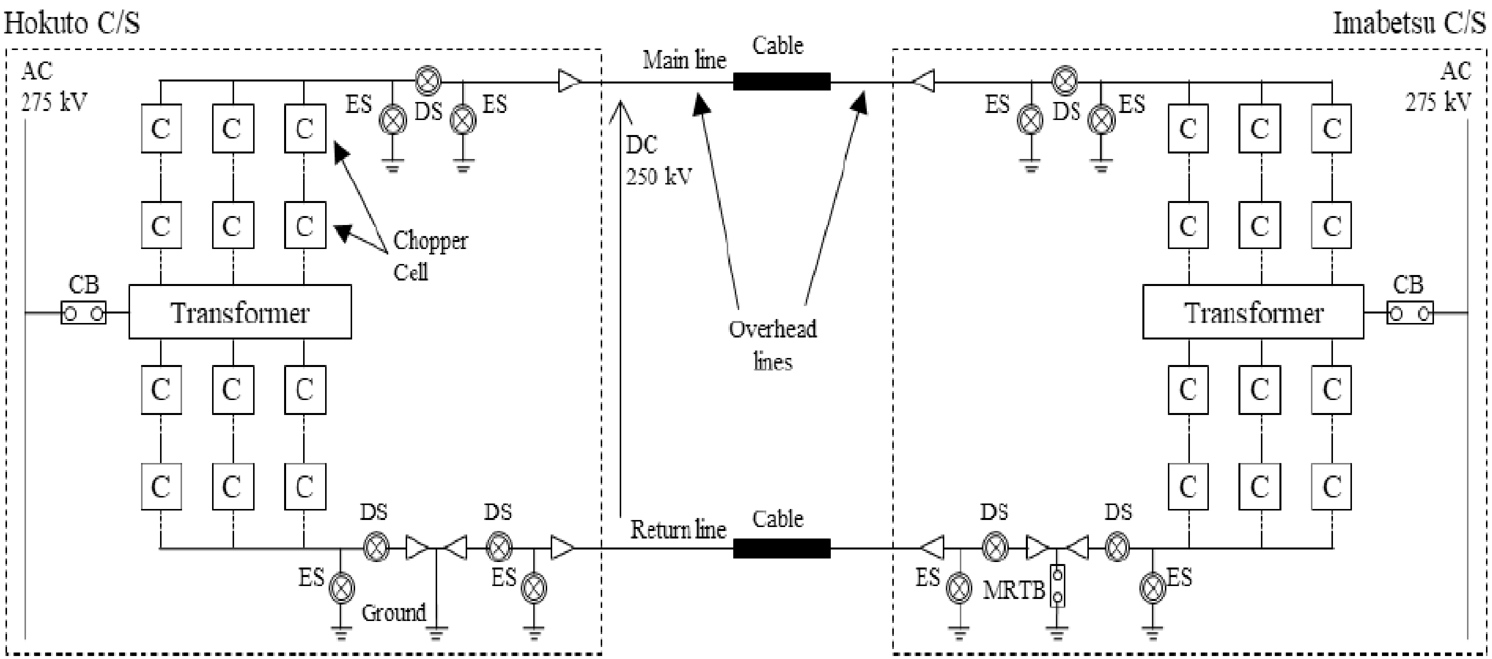
2012

60MW FC Ooi Shinkansen

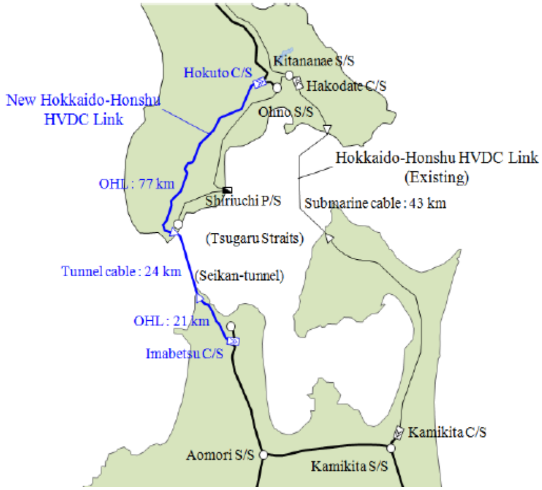


IEGT:	Injection Enhanced Gate Transistor
GTO:	Gate Turn Off Transistor
SVC:	Static Var Compensator
STATCOM:	STATic COMpensator
FC:	Frequency Converter

New Hokkaido-Honshu HVDC Link



Commissioning	March 2019
Converter type	MMC-VSC
Rated Capacity	300 MW ± 100 Mvar
DC circuit configuration	Monopole (asymmetrical)
DC voltage and current	+250 kV, 1200 A
AC voltage	275 kV (both converter stations)
Transmission distance	122 km (overhead line : 98 km, cable : 24 km)



Source: The voltage source converter applied to new Hokkaido-Honshu HVDCLink,
Cigre-IEC 2019 Conf, April 2019

Outlook of the HVDC System in the Future

LCC HVDC

- Many of its traditional applications have been taken over by the VSC
- Its robustness, high reliability, ample experience and strong supply can be attractive
- It is inherently immune to the DC fault
- Much cheaper than the MMC for high power applications
- Extra powerful systems have been built and are working well
- uHVDCs reach to 3 – 12 GW, V_{DC} at 800/1100 kV for bulk power transmission over extra-long distances
- Working together with SC, SVC or STATCOM can be a valid and economic solution
- To be further developed into hybrid HVDC systems and multi-terminal HVDC

Outlook of the HVDC Industry in the Future

VSC HVDC Applications

- The MMC technology is a focus point in VSC systems
- The right technology for offshore wind and solar power plants
- Other features like controllability, lower harmonics, reduced space, connection ability etc. are increasingly appreciated
- Move to transmission systems with even higher power capability
- New systems like multiple-terminal, hybrid HVDC and DC grid are starting to emerge

Outlook of the HVDC Industry in the Future

VSC Technology Development

- System development at pace
- Systems get very complicated with a lot of uncertainties
- Raise the power level
- Reduce the losses
- Improve the reliability
- Reduce the cost

Conclusions

- HVDC system has been bringing many benefits to modern power systems, but it also brings in many challenges, making the power grid very complicated.
- This are the reasons why we need modelling, analysis and studies in order to fully understand such a complicated network.
- This is one of the tasks why we are here today

Thank you for your attention

