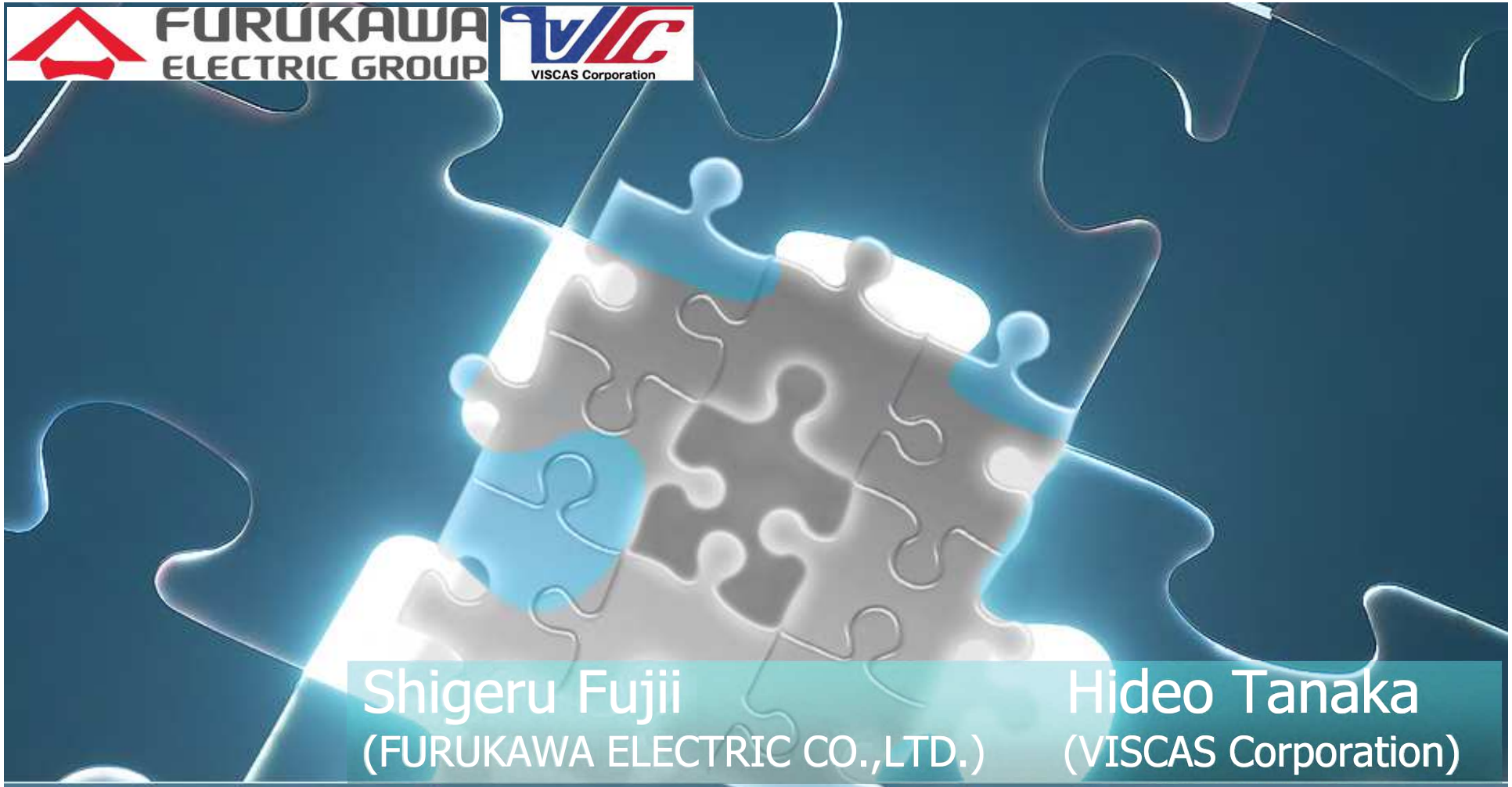


Shigeru Fujii
(FURUKAWA ELECTRIC CO.,LTD.)

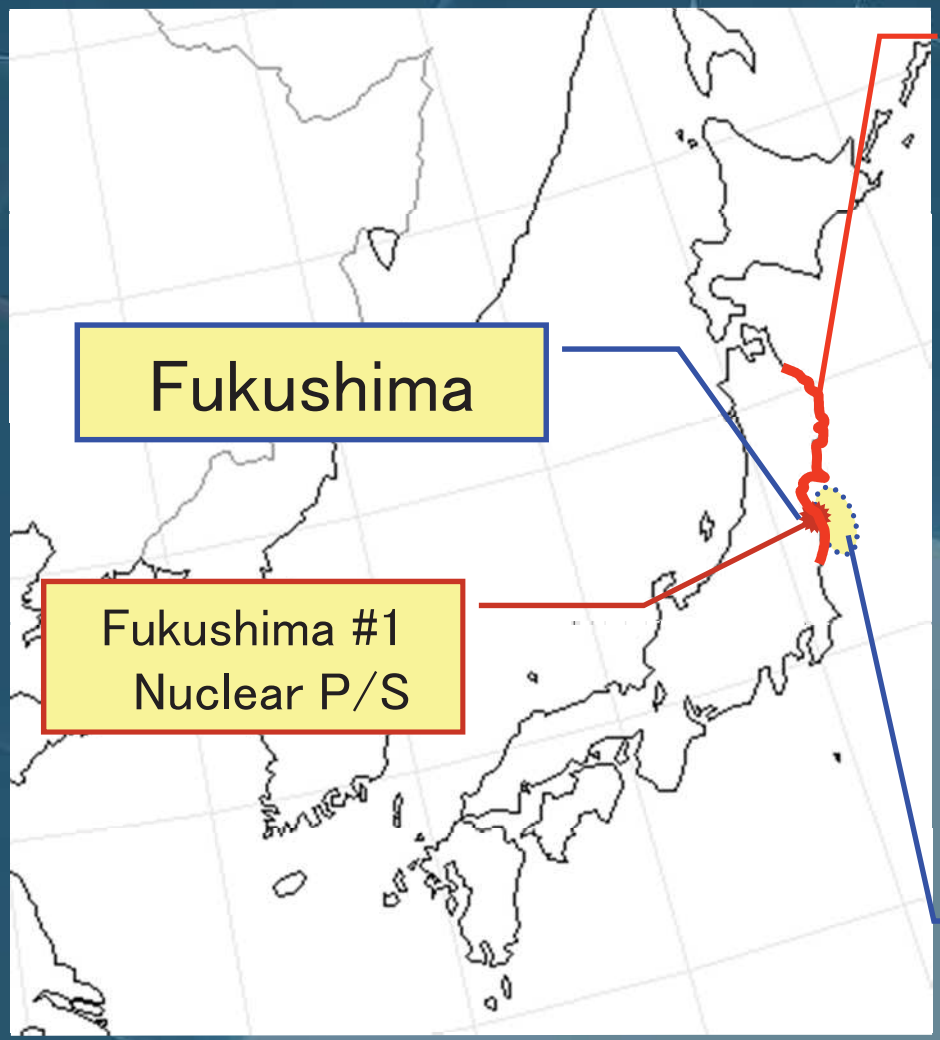
Hideo Tanaka
(VISCAS Corporation)

Sub C in 2013 Fall ICC Meeting

# Power transmission system for "Fukushima FORWARD Project"

## -- Power cable system for offshore floating type wind farm pilot plant --

# Project Location




Tsunami Damaged Area

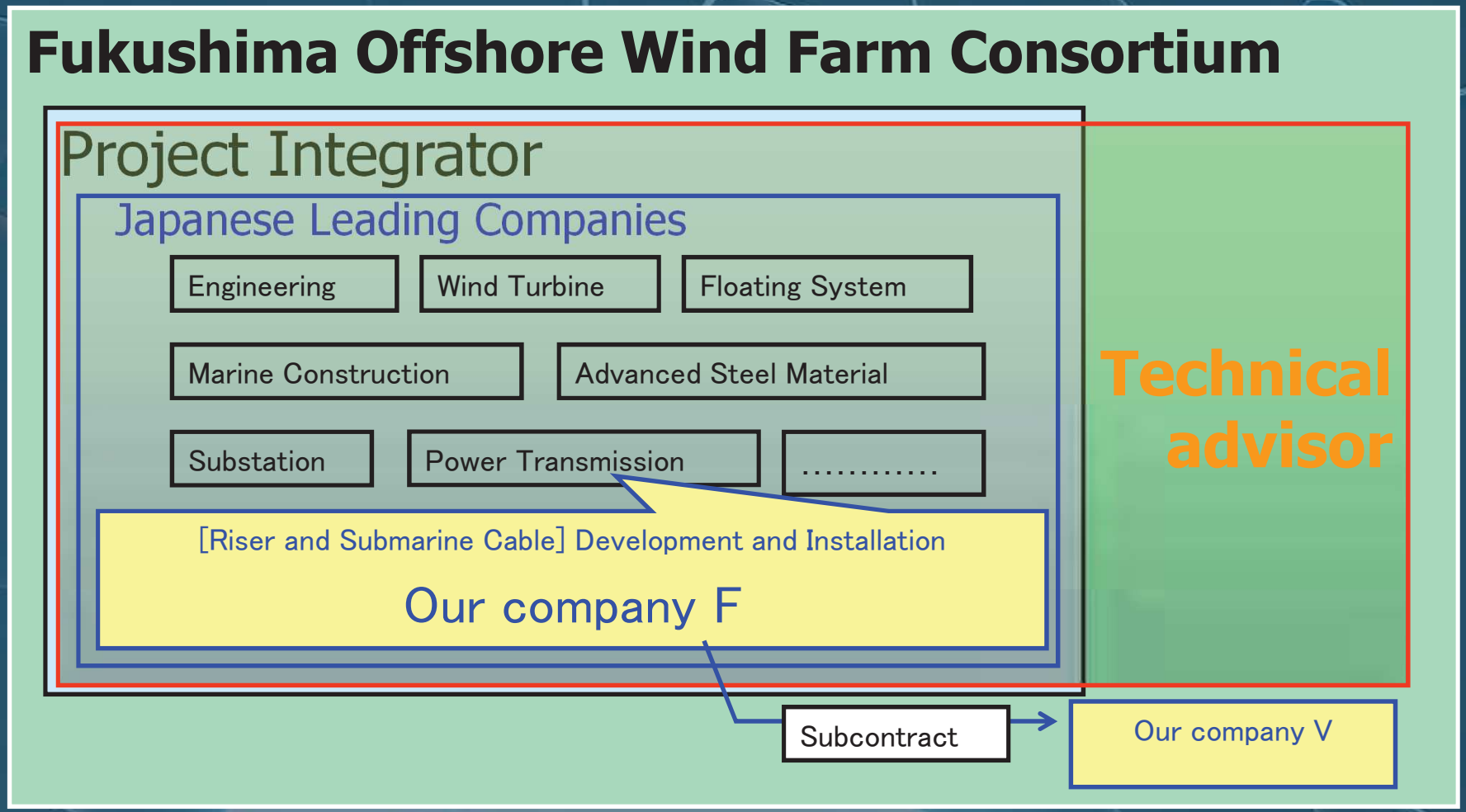
March 11. 2011, extra large earthquake took place in East-North Japan and resulted extremely severe damage in that area as well as Fukushima #1 nuclear P/S.

Project Area

# Project Target

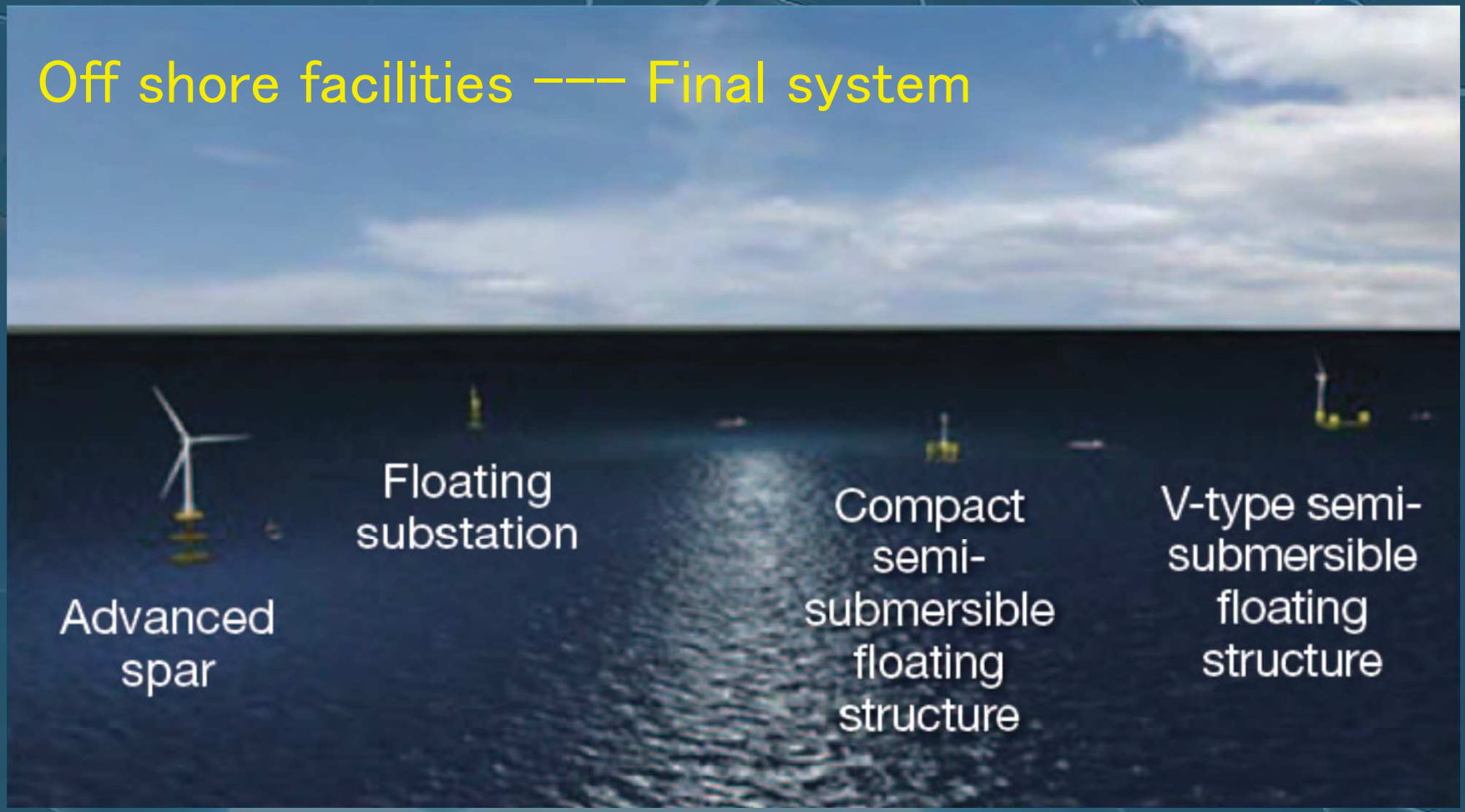
- Offshore floating wind farm project
  - ✓ Introduction of new renewable energy
  - ✓ Trial project of total system verification
  - ✓ Potential availability of wind energy in Japanese EEZ
  - ✓ To help industrial revival of Tsunami-damaged regions in Fukushima Prefecture
- To be performed as consortium project financed by Japanese government

# Project formation



# Project Outline (1)

Off shore facilities --- Final system



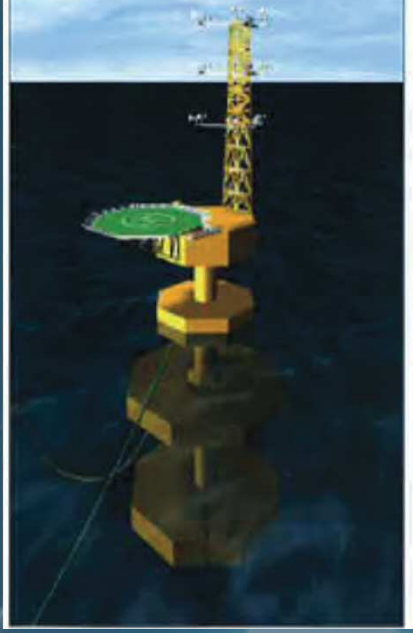

Source :Fukushima Offshore Wind Farm Consortium

# Project Outline (2)

1st Stage 2011-2013

2nd Stage 2014-2015

25MVA
Floating S/S



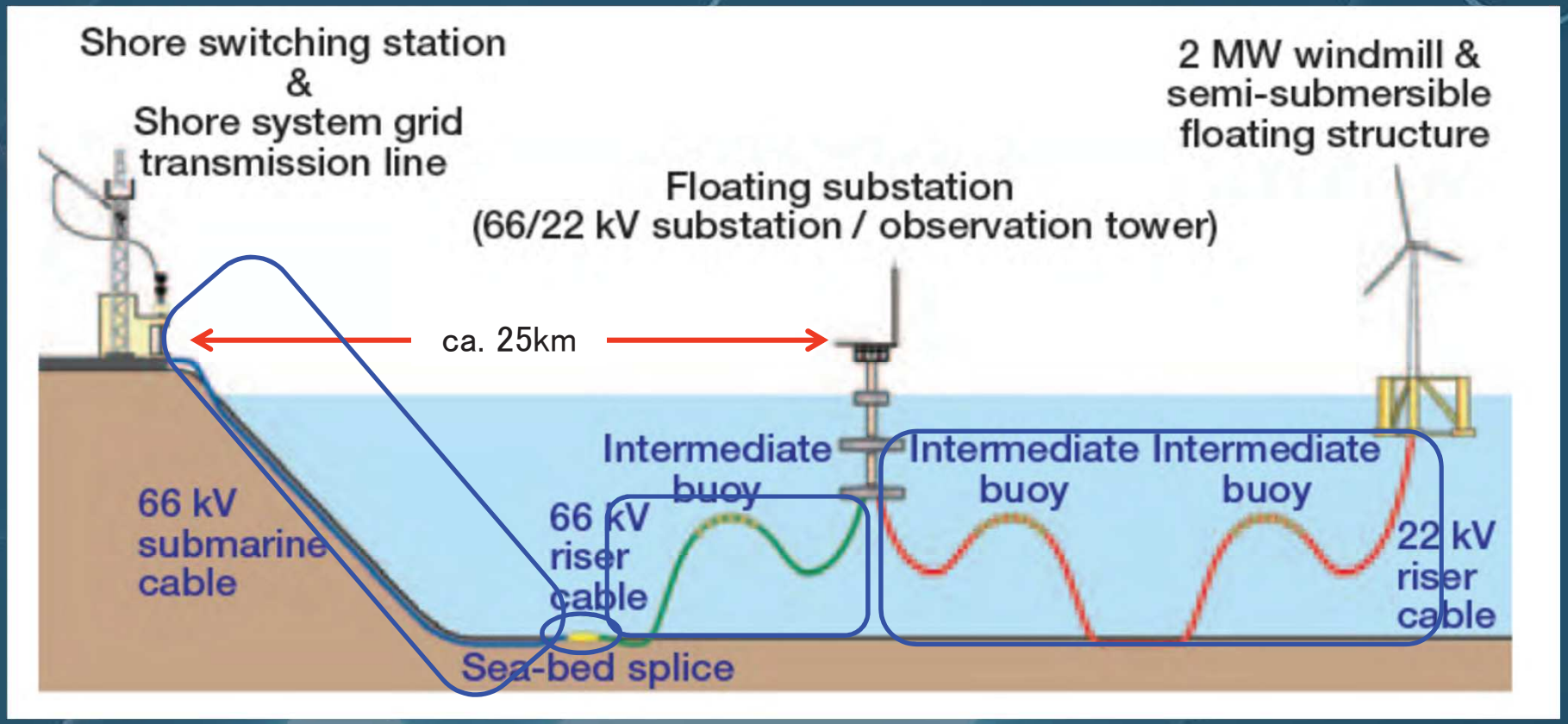
2MW Turbine

7MW Turbine-1

7MW Turbine-2

Source :Fukushima Offshore Wind Farm Consortium

# Power Transmission System
# 1st stage outline






Source :Fukushima Offshore Wind Farm Consortium

# Development of Riser Cable

Cigre TB-490

JEC-3408

Cigre Electra No.171

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+

**Target characteristics.**

| Item | Target characteristics |
|---|---|
| Sea condition at installation site | ・Meet allowable tension and minimum bending radius in floating condition |
| Floating structure rolling condition | ・Floating part of the cable should not touch the sea bed<br>・Cable should not be kinked |
| Fatigue life design | ・Similar to windmill or floating structure |

**Wave conditions.**

| Item | Adoption value |
|---|---|
| The 50-year-period-return value associated with a storm wave | Significant wave height(note) 11.71 m |
| | Significant wave period 13 sec. |
| Sea current | 1.5 m/s (including drift current) |

(Note) The average wave height is defined as the average values from the highest record and the consecutive values of 1/3 measurements of the total measurements recorded of the period of recording (for example 20 min) at a certain point.

Static behavior analysis

Dynamic behavior analysis

Fatigue analysis

OK

Riser Cable Design

# Outline Spec. of Riser Cables

| | Unit | 66kV | 22kV |
|---|---|---|---|
| Outer Diameter of Cable | mm | 175 | 150 |
| Cable Weight | kg/m (in air) | 53 | 43 |
| Moisture/Water barrier | ---- | Corrugated Stainless Steel Sheath | Stainless Steel Foil Laminated Tape |
| Optical Fiber Unit | ---- | 8 fibers x 3 unit | 8 fibers x 1 unit |
| Steel Armor | ---- | Two Layers | |

# Important Aspects of Riser Cable System Development

- 22kV Riser Cable
  - Moisture/Water barrier structure and its properties
  - Mechanical properties for dynamic movements
- 66kV Riser Cable
  - Mechanical properties for dynamic movements
- Transition Joint (66kV Riser to Submarine)
  - Water pressure resistance
  - Tensile strength on conductor joint sleeve as well as whole structure

# Design Flow of Riser Cable (1)

START

Sea condition & FS* condition

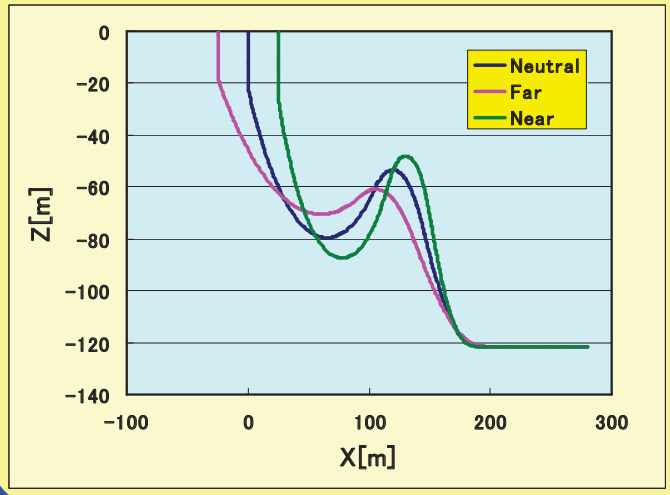
Cable parameters

*FS: Floating Structure

Calculation of Cable profile

Static & Dynamic Behavior Analysis

Cable profile in water




Cables can bear FS movement

NG

Redesign

OK

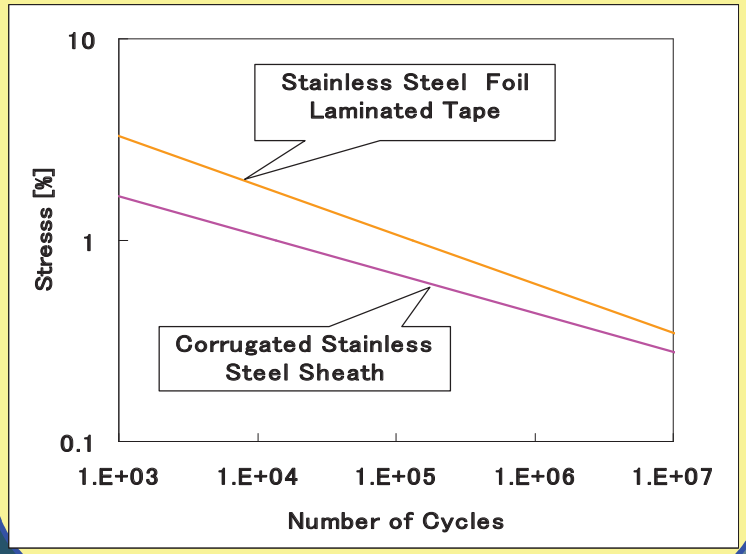
# Design Flow of Riser Cable (2)

Cable strain fatigue property

Fatigue analysis

Wave height & frequency statistics

Strain fatigue property




Cumulative fatigue for design life time

NG

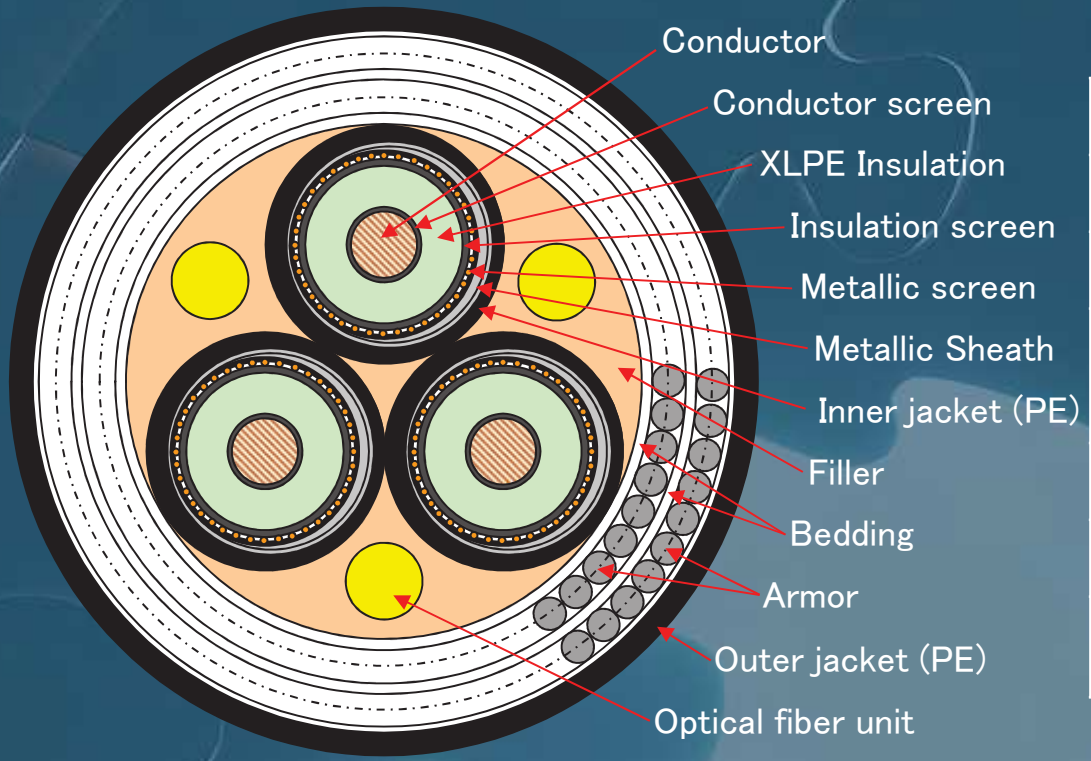
Redesign

OK

END

# Design of 66kV Riser Cable

## Water Blocking Structure with Corrugated Stainless Steel Sheath




| | |
|---|---|
| Conductor | 3 x 100 $mm^2$ |
| XLPE Insulation | 11 mm |
| Inner PE jacket | 3.5 mm |
| Armour | Galvanized steel wire (6.0 mm) |
| Outer PE jacket | 6 mm |
| Outer diameter | 175 mm |
| Weight | 53 kg/m in air |

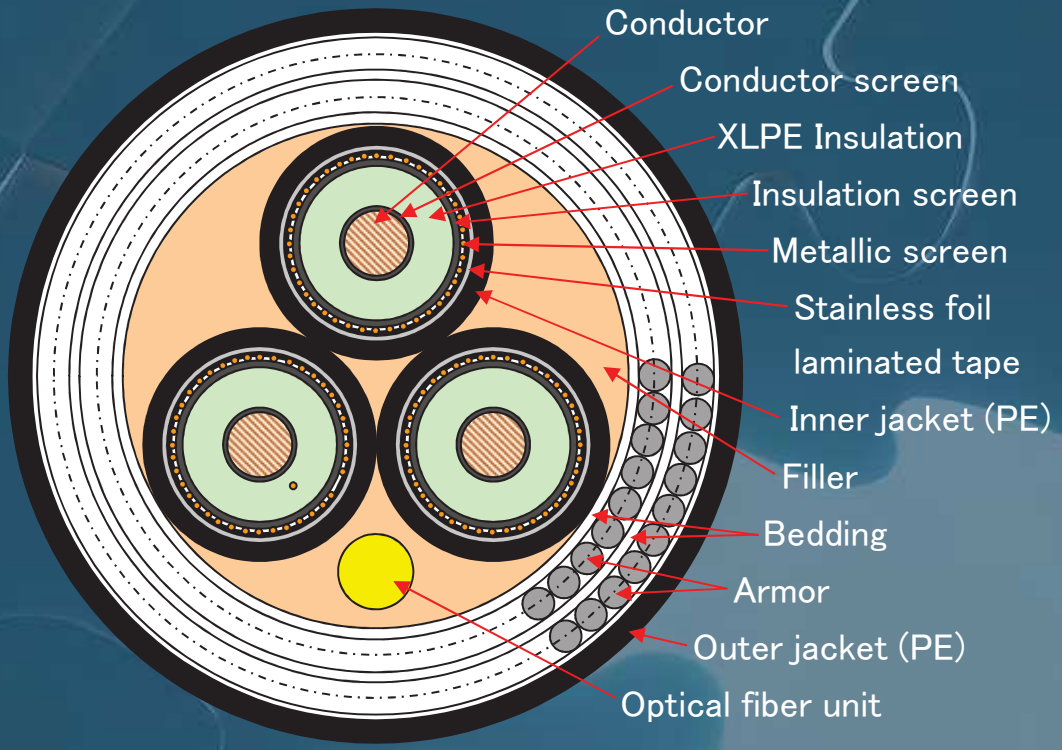
Installed cable length: 860m

# 66kV Riser Cable

66kV Riser Cable

# 22kV Riser Cable

## Water Blocking Structure with Stainless Steel Foil Laminated Tape



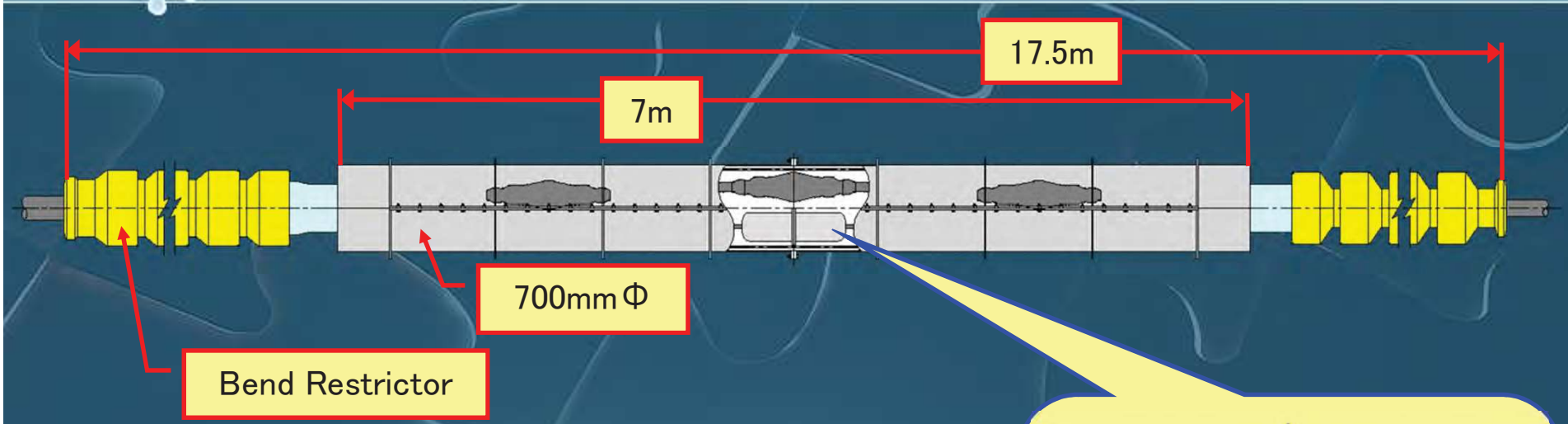

Installed cable length: 2340m

| | |
|---|---|
| Conductor | 3 x 150 $mm^2$ |
| XLPE Insulation | 6 mm |
| Metallic sheath | Stainless steel foil laminated tape(0.6mm) |
| Inner PE jacket | 3.5 mm |
| Armour | Galvanized steel wire (6.0 mm) |
| Outer PE jacket | 6 mm |
| Outer diameter | 147 mm |
| Weight | 43 kg/m in air |

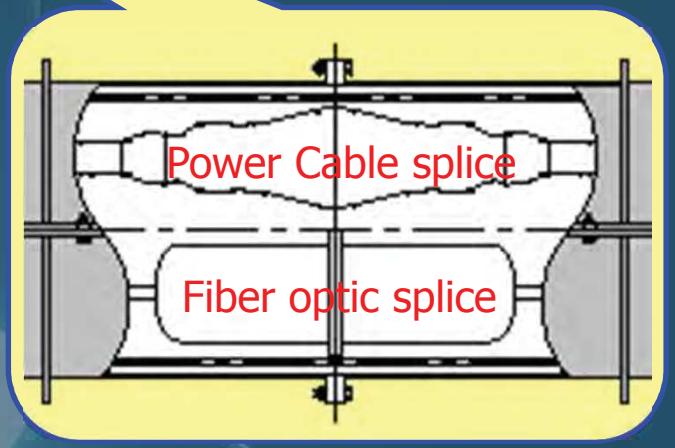
# 22kV Riser Cable

22kV Riser Cable

# Design of 66kV transition joint between riser and submarine cable




| | |
|---|---|
| Water Pressure Resistance | 1.5MPa OK |
| Tensile Strength on Conductor Joint Sleeve | > 7kN |

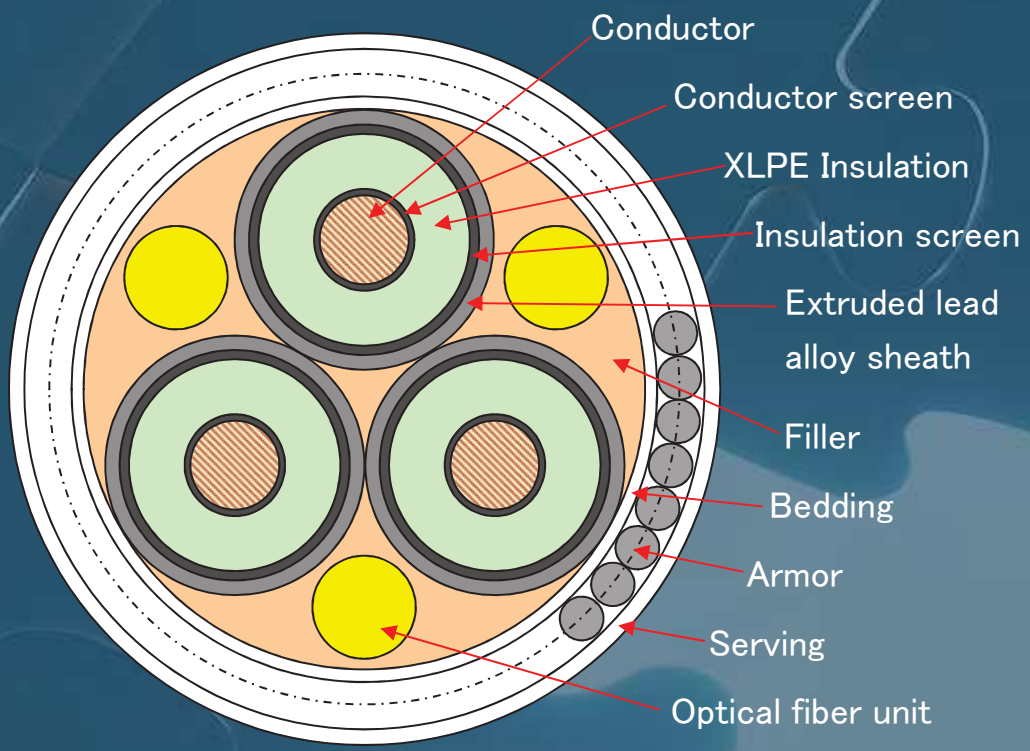



Rigid joint worked on the laying vessel

# 66kV transition joint between riser and submarine cable

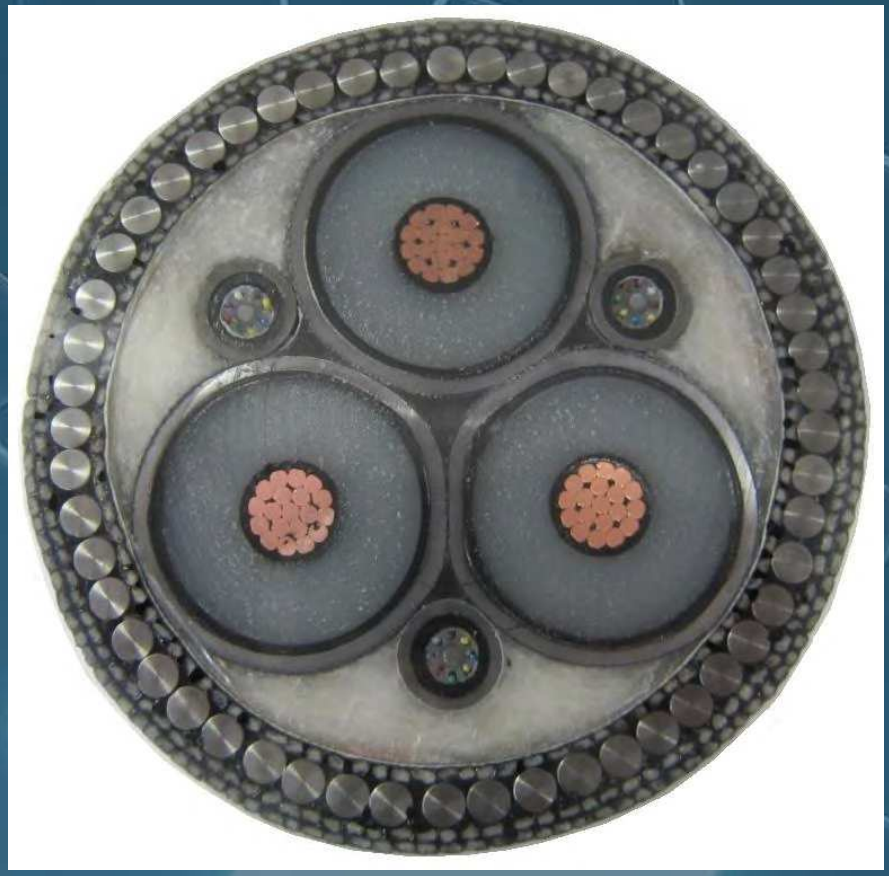
66kV transition joint on the laying vessel

# Design of 66kV submarine cable




| | |
|---|---|
| Conductor | 3 x 100 $mm^2$ |
| XLPE Insulation | 11 mm |
| Metallic sheath | Extruded lead alloy (2 mm) |
| Armour | Galvanized steel wire (6.0 mm) |
| Outer diameter | 123 mm |
| Weight | 32 kg/m in air |

# 66kV submarine cable



66kV submarine cable

# Project Schedule
# 1st stage project completed

- Cable production:
  ~2013 Summer
- Riser cable installation:
  ~2013 August-September
- System commissioning:
  2013 October
- 1st stage project in operation:
  2013 November~

# Riser Cables Installation (1)

Laying vessel

66kV riser laying at S/S

Bend stiffner

Chinese finger

Cable turn table


ROV

# Riser Cables Installation (2)

2MW Wind turbine

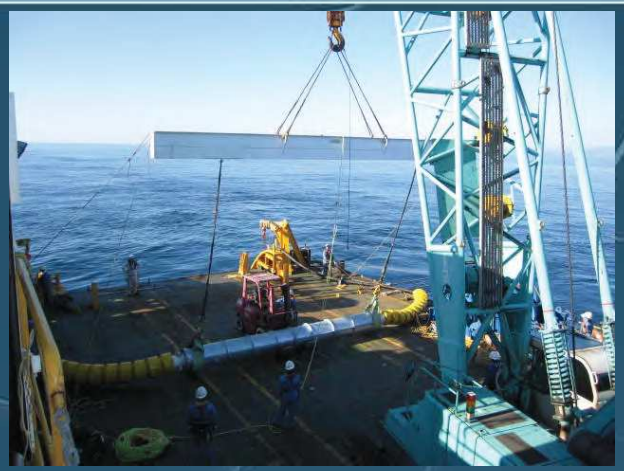
22kV riser laying at S/S

Floating S/S

22kV riser laying at turbine

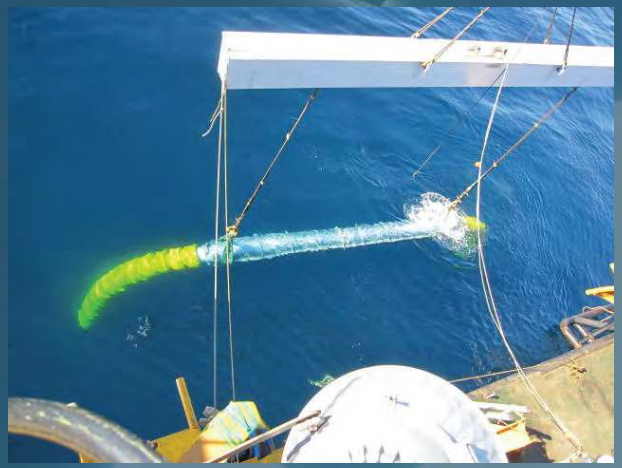
22kV riser below turbine

# Riser Cables Installation (3)



Transition joint on the vessel

Joint laying



Joint is going into sea

Joint on the sea bed

# Riser Cables Installation (4)

- On-site test for final Inspection

| | |
|---|---|
| 66kV cables | DC 151.8kV x 10min. Passed |
| 22kV cables | DC 57.5kV x 10min. Passed |

On-site test for 66kV Cable

On-site test for 22kV Cable

# 2nd Stage Project Outline





1st Stage

22kV Riser Cable

66kV Riser Cable

Transition joint

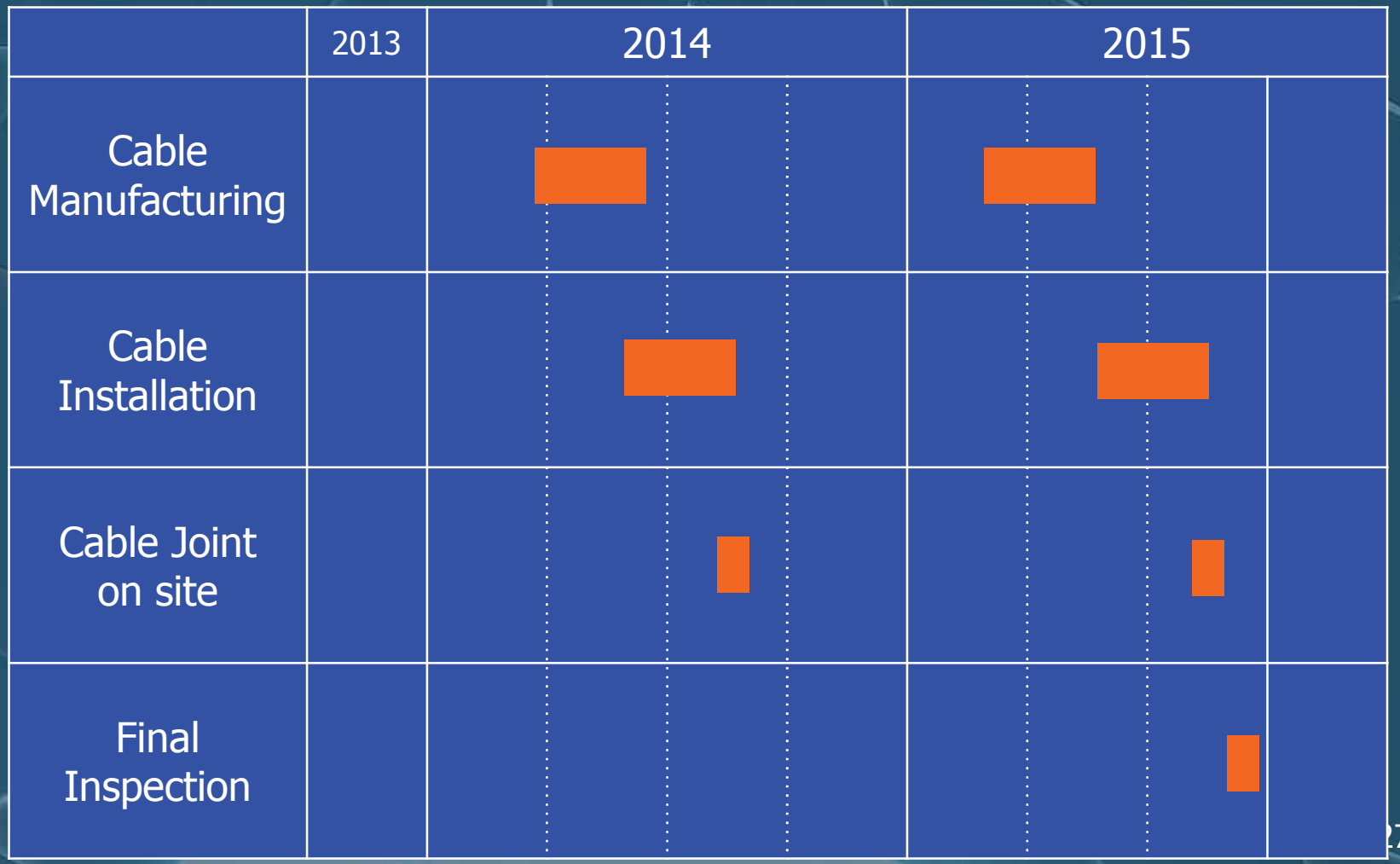
66kV Submarine Cable

22kV Riser Cable

2nd Stage

Source :Fukushima Offshore Wind Farm Consortium

# 2nd Stage Project Schedule



# Thank you for your attention!

References: [1] Fujii, et. al.; "The Development of the Power Transmission System for Fukushima FORWARD Project", Furukawa Review 43, (March 2013)
[2] Fukushima Offshore Wind Farm Consortium, Brochure on Fukushima FORWARD Project

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