

# Experience in service of HVDC cables, prospects of extruded polymer insulation

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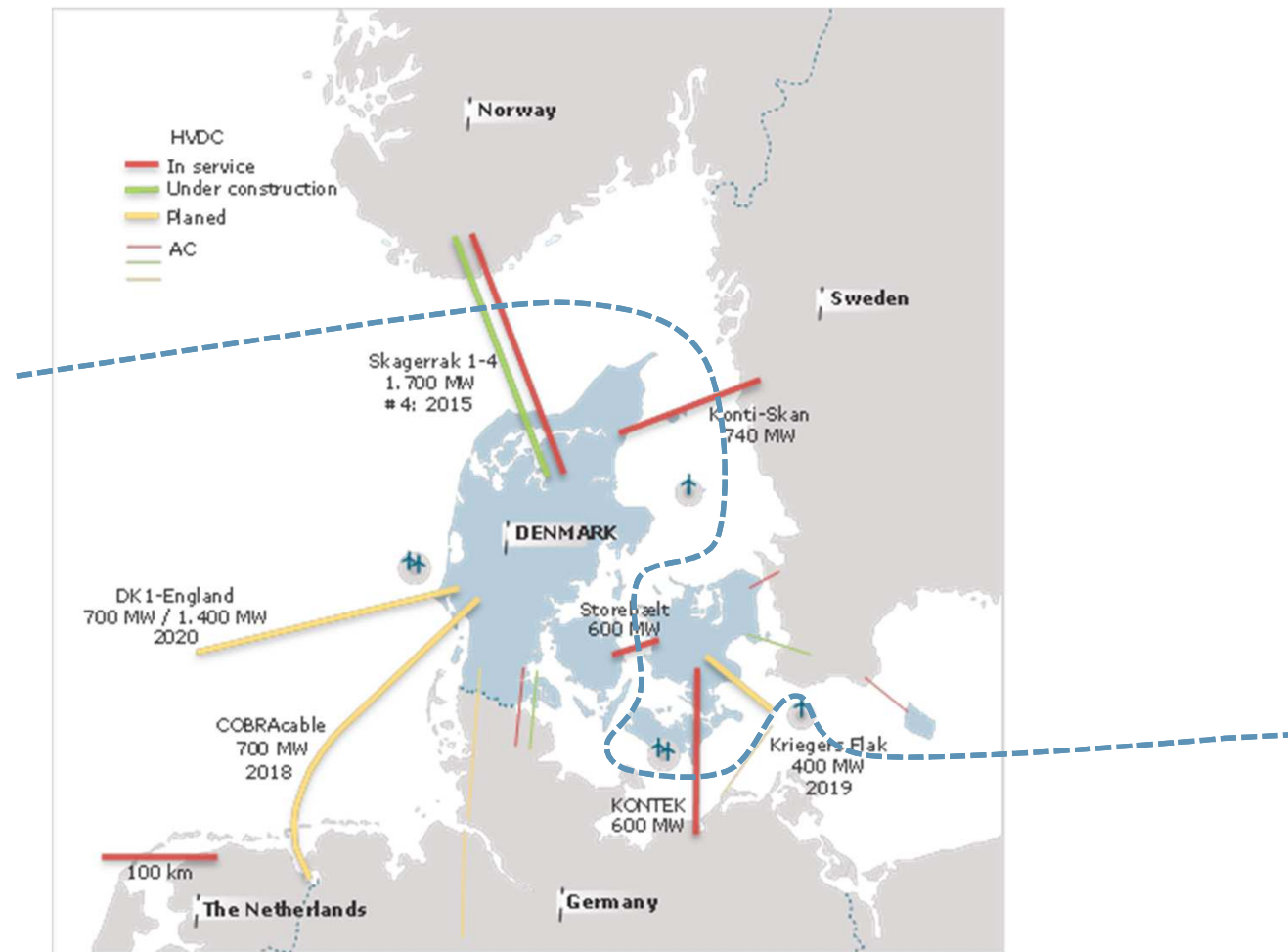


# ENERGINET/DK Facts

- We are the National Danish Transmission System Operator (TSO).
- Independent public enterprise under the Ministry of Climate, Energy and Building
- Owns and operates the overall grid on Gas and Electricity (>100 kV)
- Approx. 650 employees
- Annual revenue: 1 billion EUR (2011)
- The consumers pay for our activities through tariffs on El. and Gas
- We are not allowed to make a profit



# Energinet.dk HVDC Links



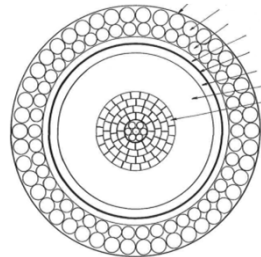


# Existing HVDC Links

- **Connections to Sweden (LCC) (læsø)**
  - Konti-Skan 1 & 2
    - 2 x 23 km submarine cable from 1965/1971 – flat type oil filled
      - Bothe: 250 kV, 250 MW, 2x310 mm<sup>2</sup> Cu
    - 23 km submarine cable from 1988 – Flat type oil filled
      - 285 kV, 300 MW 2x500 mm<sup>2</sup> Cu



- **Connections to Norway (LCC)**
  - Skagerrak 1 & 2 (bipole)
    - 2 x 127 km submarine cable from 1976-1977 – single core MIND
    - 250 kV, 250 MW, 800 mm<sup>2</sup> Cu
  - Skagerrak 3 (asymmetric bipole with 1 & 2)
    - 127 km submarine cable from 1993 – single core MIND
    - 350 kV, 440 MW, 1400 mm<sup>2</sup> Cu





# Existing HVDC Links

- **Connection to Germany (LCC - monopole)**
  - Kontek
    - 101 km land cables from 1995 – flat type oil filled
      - 400 kV, 500 MW, 2x800 mm<sup>2</sup> Cu
    - 50 km submarine cable from 2010 – Single core MIND
      - 400 kV, 550 MW, 1850 mm<sup>2</sup> Cu (replacing a Flat type oil filled, from 1995)
- **Connecting Eastern and Western Denmark (LCC - Monopole with metallic return)**
  - Great Belt connection
    - 25 km landcable from 2010 – single core, MIND
    - 32 km submarine cable from 2010 – single core, MIND
      - 400 kV, 600 MW, 1600/2100 mm<sup>2</sup> Cu (sea)
      - 1700 mm<sup>2</sup> Cu (land)



# Technical Issues

- **Kontek - Exchanging old Flat Type Oil Filled submarine cables**
  - Systematic crack formation at joints (joints for every 1000 meters)
  - Original cable design - Flat Type Oil Filled
  - New submarine cable: Single core MIND cable.
  - Two types of cables connected via open air terminations
  - placed in buildings mostly under (three landings in DK)

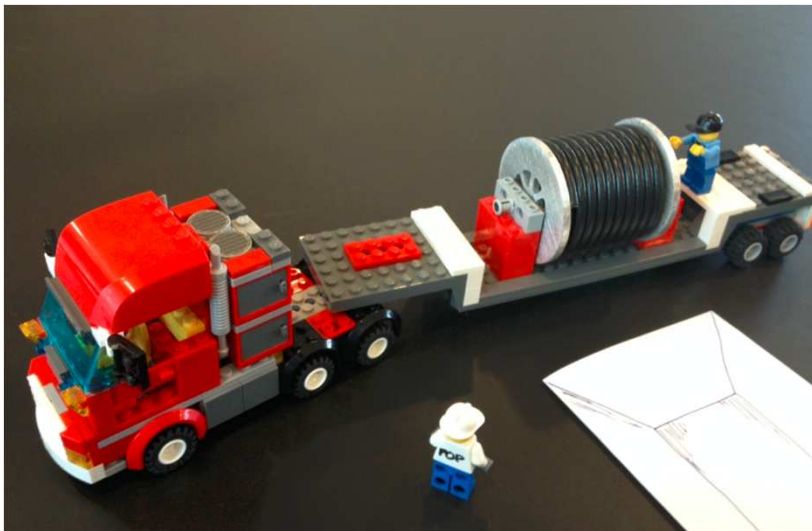






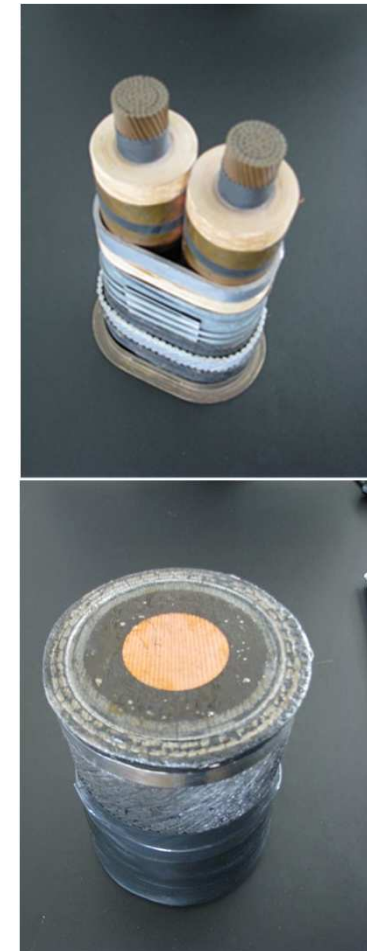
# Onshore Installation MIND

- **Long cable sections, SK4**
  - 1600 m long cable sections on land,
    - For long HDD under water, and to save joints (normal 1400 m)
  - Drum size: 7.6 m x Ø4.2 m, up to 100 ton.
  - New cable pulling vehicle constructed



# Operational Experience

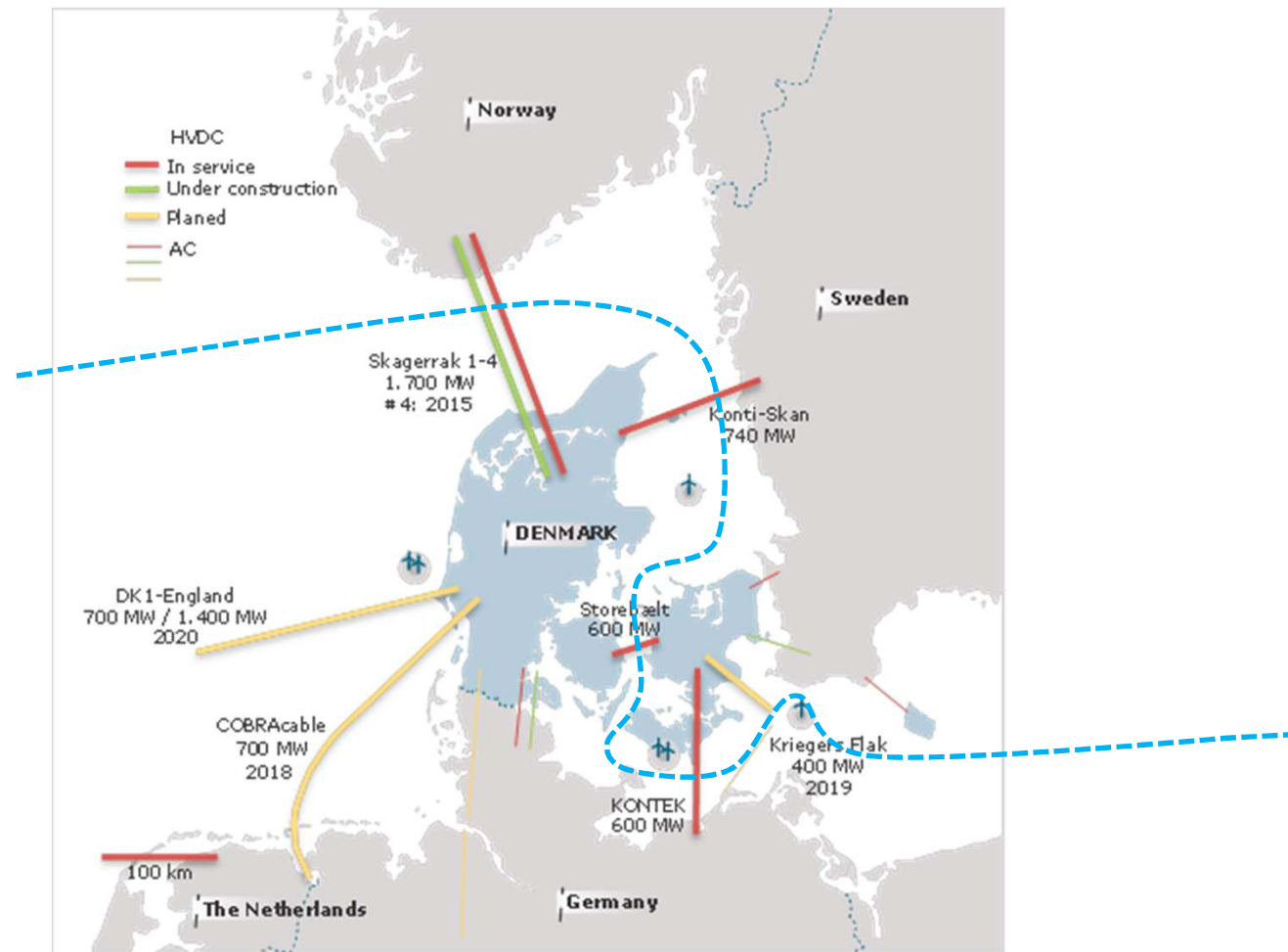
- **700 km route of installed DC cables - average age 24, max 48**
- Operational experience with FTOF
  - 175 km installed length (+50 km replaced)
  - External damages
  - Fatigue of lead sheath
    - Error in production
    - Joints/construction (AC design)
- Operational experience with MIND
  - 490 km installed length
  - External damages only!
  - So far very good







# Energinet.dk HVDC Links





# Ongoing Projects 1

- **Connection to Norway (VSC – bipole with SK3 LCC) done**

- Skagerrak 4

- 140 km submarine cable
  - 1600 mm<sup>2</sup> - single core MIND
- 104 km underground cable
  - 1600 mm<sup>2</sup> - single core MIND
  - Installation lengths 1300-1650 meters
- 525kV, 700 MW, (total 1 700 MW)



- **Connections to Sweden (LCC) (læsø)**

- Exchanging the first Konti-Skan 1 from 1965

- 1 x 23 km submarine cable.  
285 kV, 300 MW, 1x1400 mm<sup>2</sup> Cu





# Ongoing projects 2

- **Kriegers Flak (VSC - bipole)**
  - Kriegers Flak
    - 2 x 82 km submarine cable
      - 2 x single core extruded HVDC cable
    - 2 x 6 km underground cable
      - 2 x single core extruded HVDC cable
    - 320kV, 600 MW



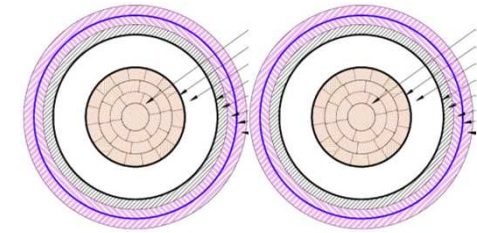


# Future Projects

- **Connection to the Netherlands (VSC – bipole)**

- COBRACable

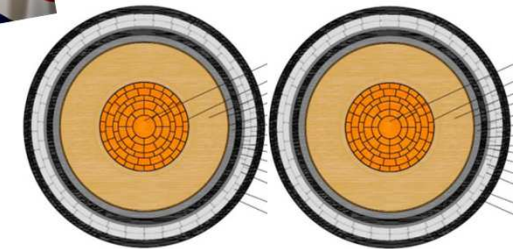
- 2 x 320 km submarine cable
- 2 x 50 km underground cable
- 320kV, 700 MW - Extruded ?



- **DK1 – UK (VSC - bipole)**

- DK1-UK

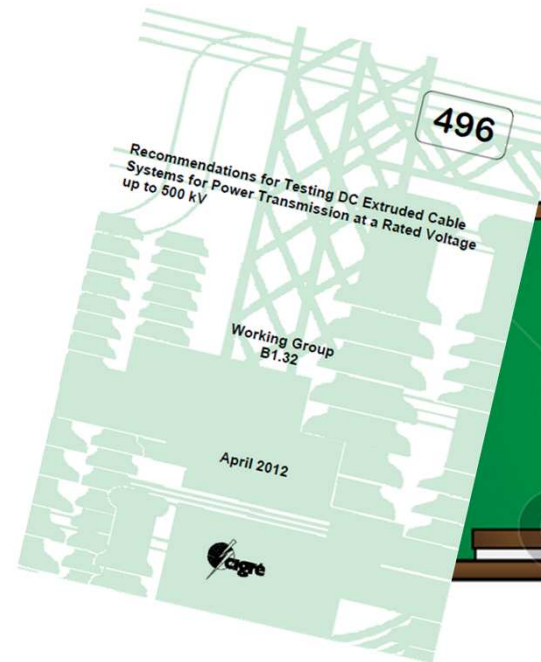
- 2 x ≈600 km submarine cable
- 2 x ≈ 50 km underground cable
- 320kV, 700/1400 MW - Extruded ?



# Extruded DC cables

## What will Energinet.DK look for:

- Testing (CIGRE TB 496)
  - Development
  - Prequalification
  - Type Test
- Technical Knowledge
  - Material
  - DC fields, Space Charges
- Experience



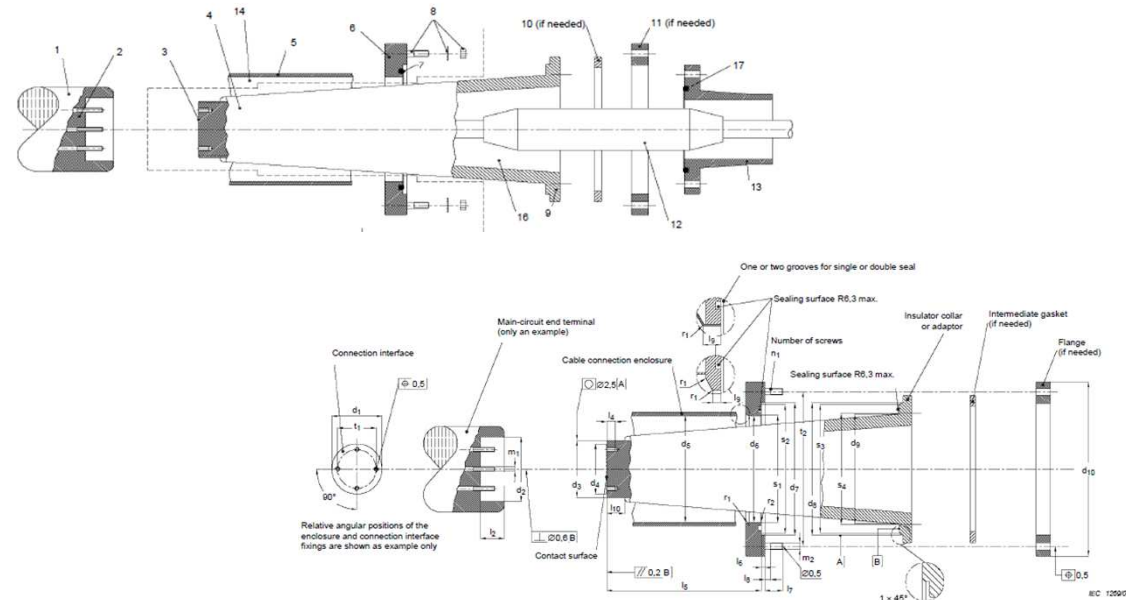
How

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# Technical Issues - GIS

- **Kriegers Flak – HVDC GIS connectors**
  - Kriegers Flak platform to accommodate at least 3 HVDC connectors (future connections)
  - Introduction of HVDC GIS to the cable system
    - Lack of Prequalification Test and Type Test
    - Availability of HVDC GIS IEC standard or other standard
    - Use of AC standard IEC 62271-209 for control of the interface between converter supplier and cable supplier?
  - Possibility to “mix and match” cable and converter supplier is limited







# Summery:

- We know and trust MIND DC cables
- Now we want Extruded DC cables
- We konw we have to be carefull when bying Extruded DC cables.



# THANK YOU FOR YOUR ATTENTION