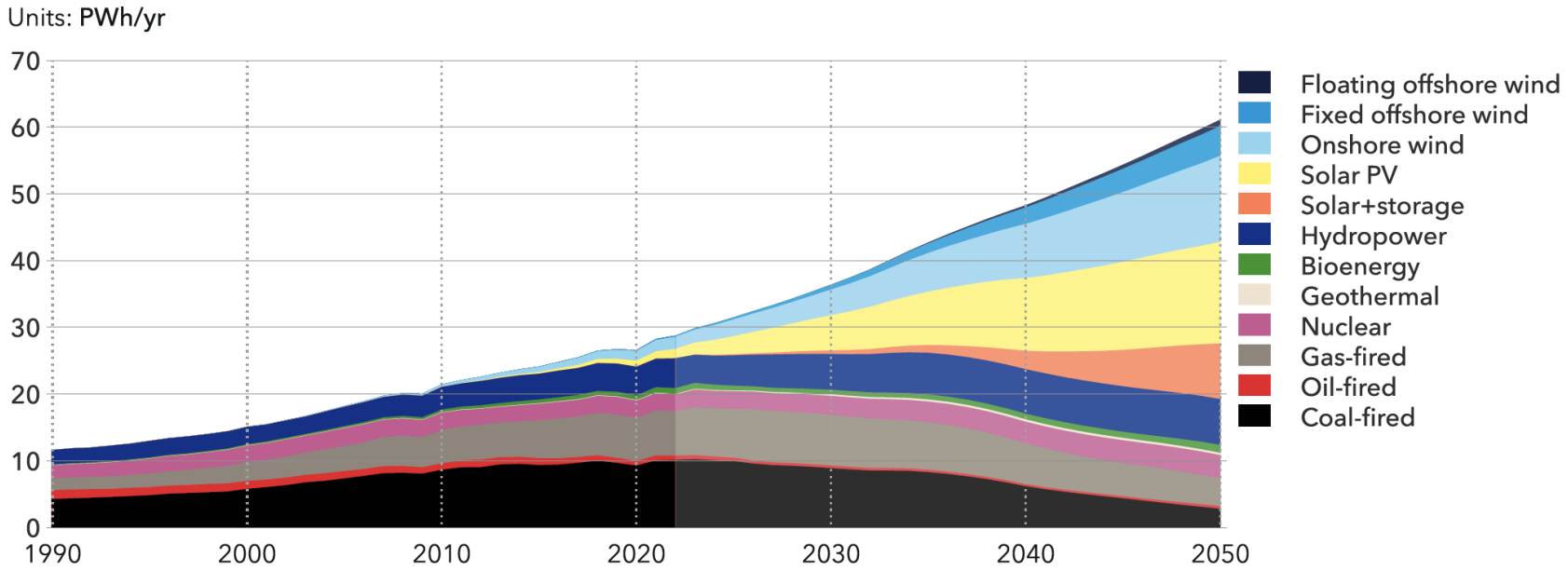
# Virtual Laboratory and the NorthWind Database of Sands

EERA DeepWind, 17-19 January 2024

Ana Page and Øyvind Torgersrud

# In 2050, 29% of the electricity will come from wind




Source: DNV's 2023 Energy Transition Outlook - Historical data source: IEA (2023), GlobalData (2023)

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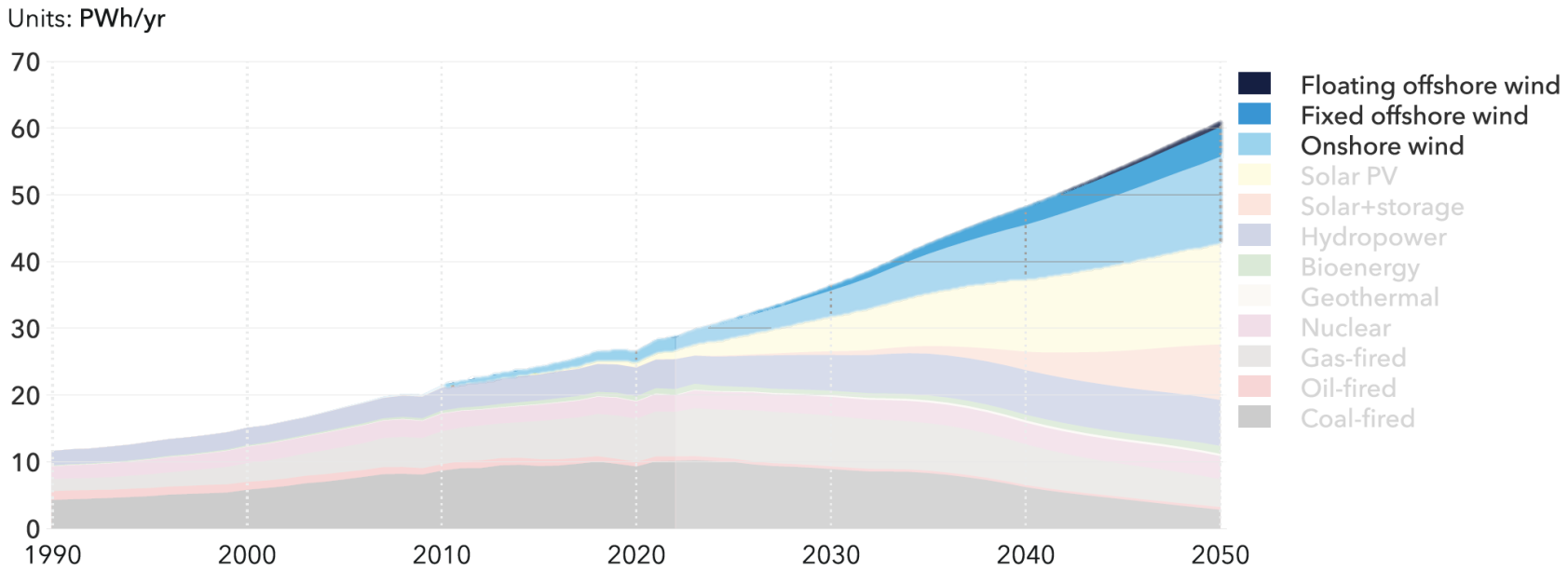


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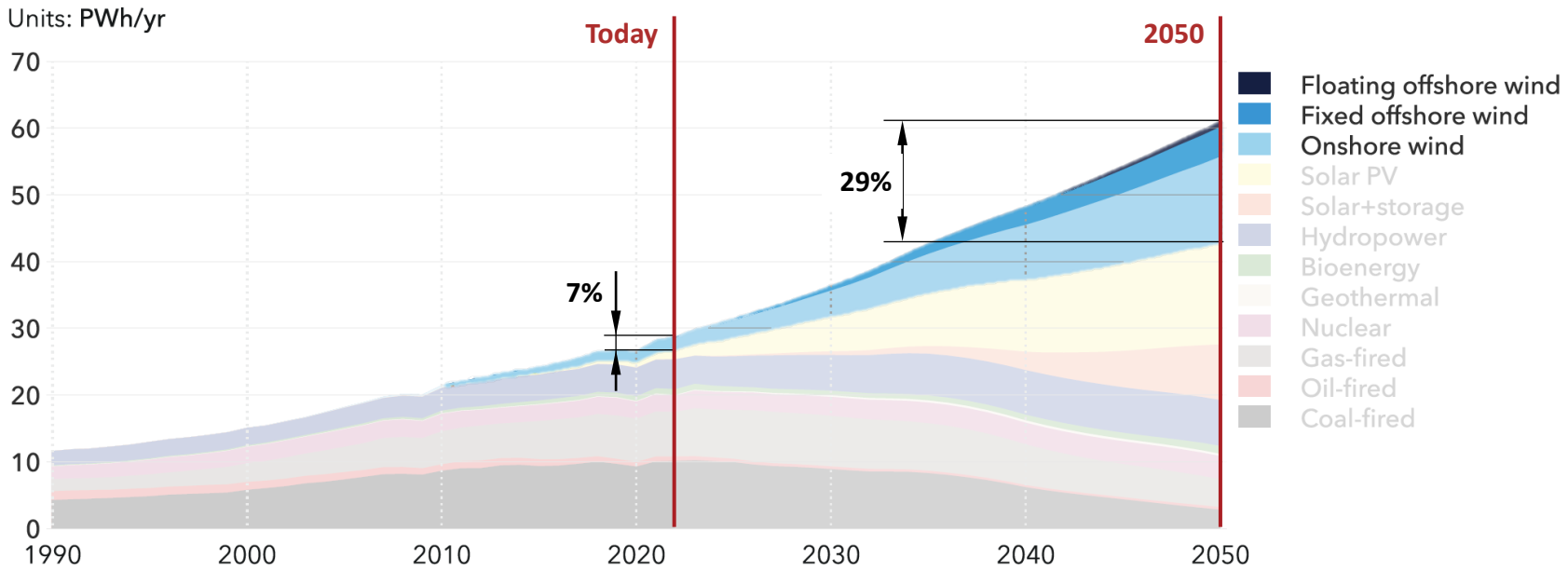


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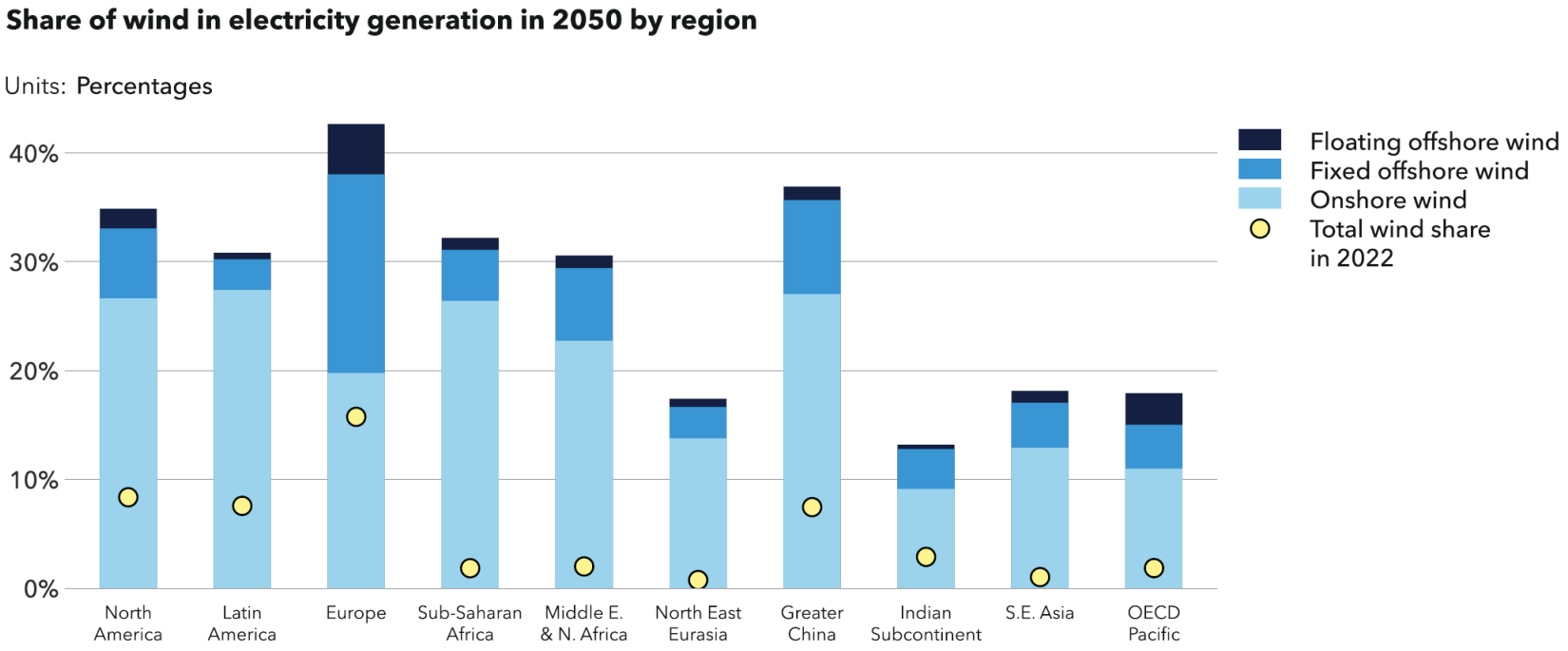
# In Europe, 22% of the electricity will come from offshore wind

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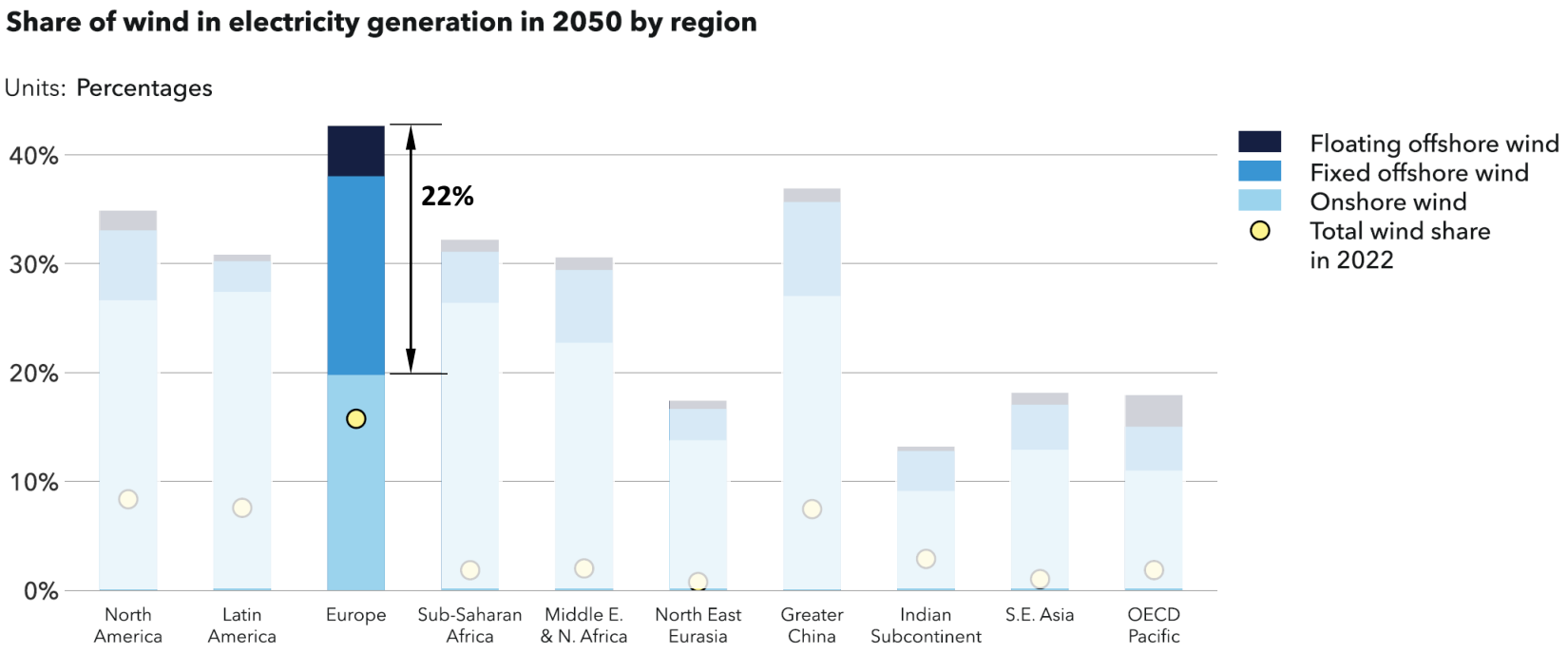


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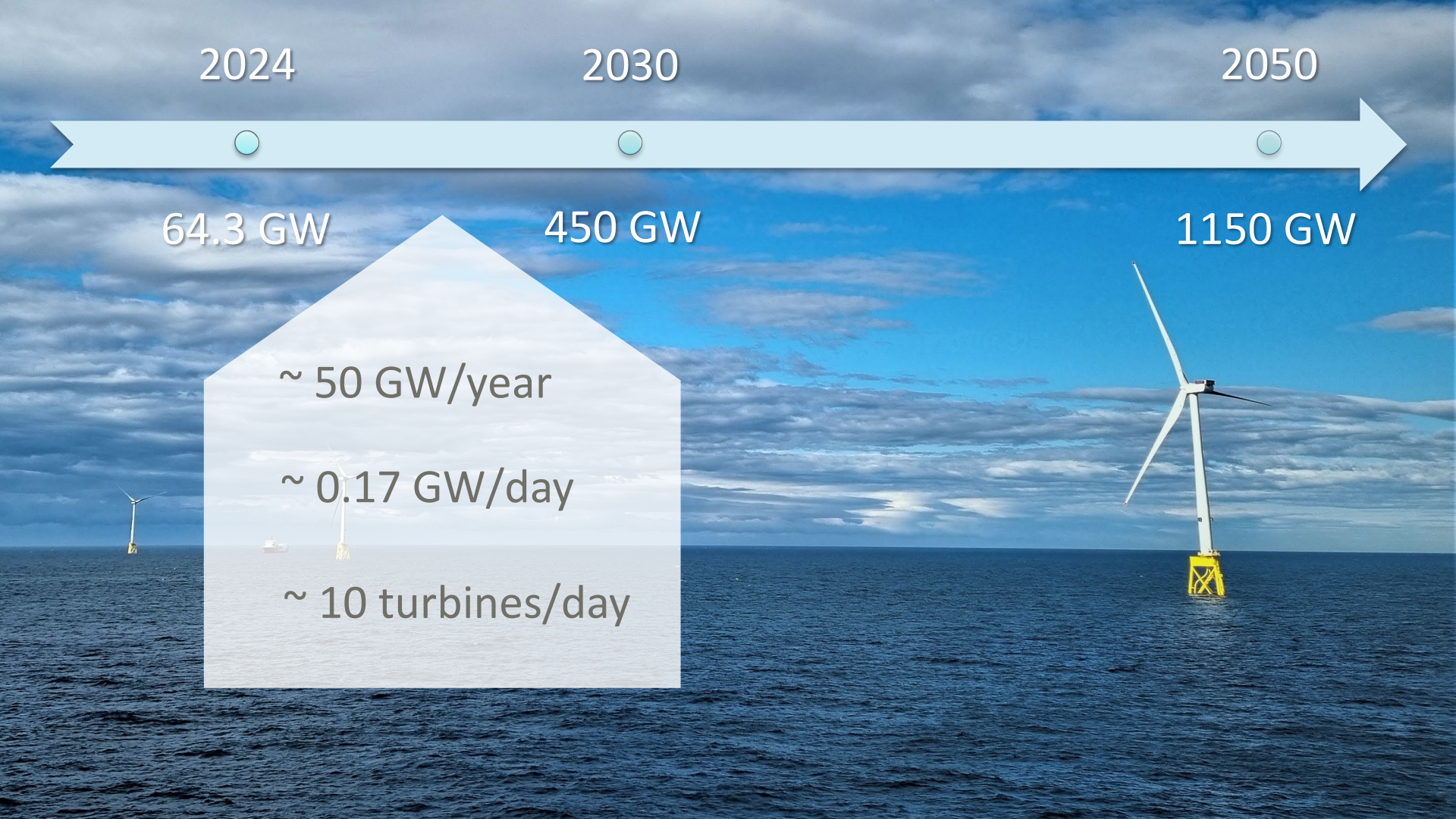
2024
2030
2050
64.3 GW
450 GW
1150 GW
~ 50 GW/year
~ 0.17 GW/day
~ 10 turbines/day


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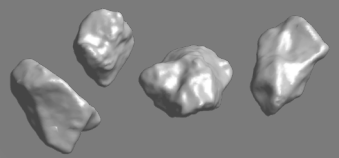
~ 0.17 GW/day
~ 10 turbines/d

We are establishing a database of accessible sand data and tool to further populate it – a virtual lab

# The ingredients

Database of grains



*LS-DEM*

*Laboratory testing*

Database of virtual laboratory tests

*Validation*

Database of physical laboratory tests

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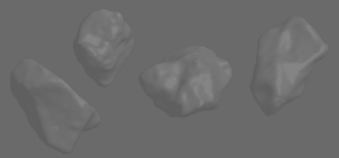

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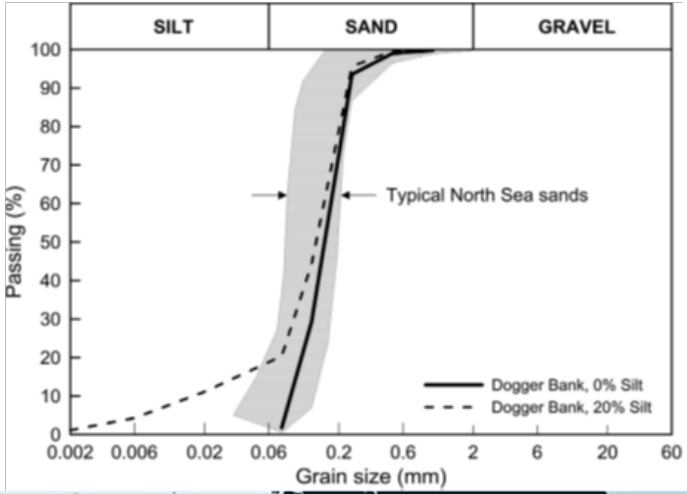
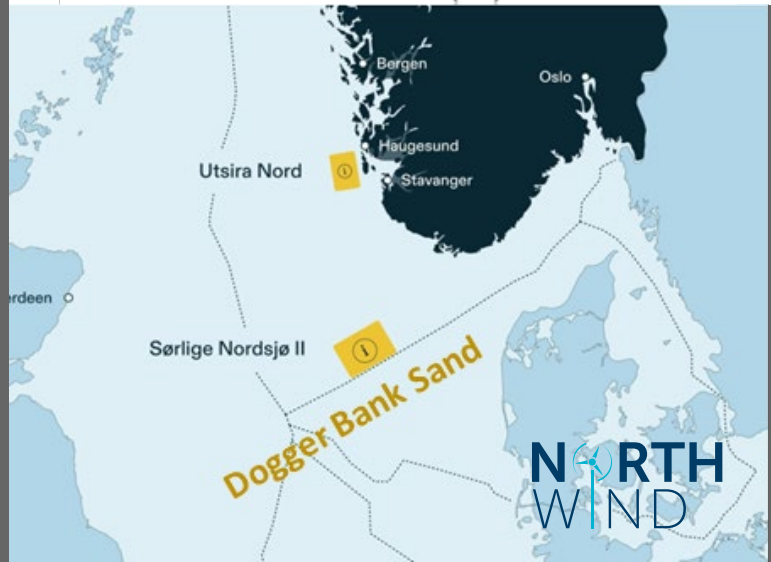
# Physical laboratory tests

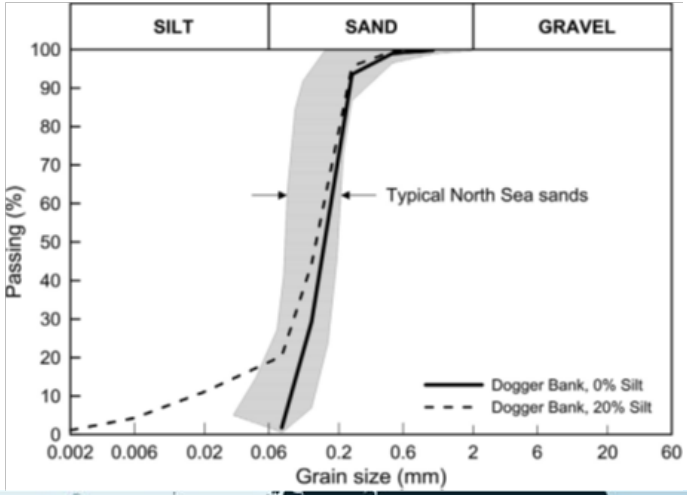
- Soils are tested in the laboratory to understand their mechanical properties (e.g. from stress-strain curves)
- This information is used in the foundation design, and it is also important to predict installations

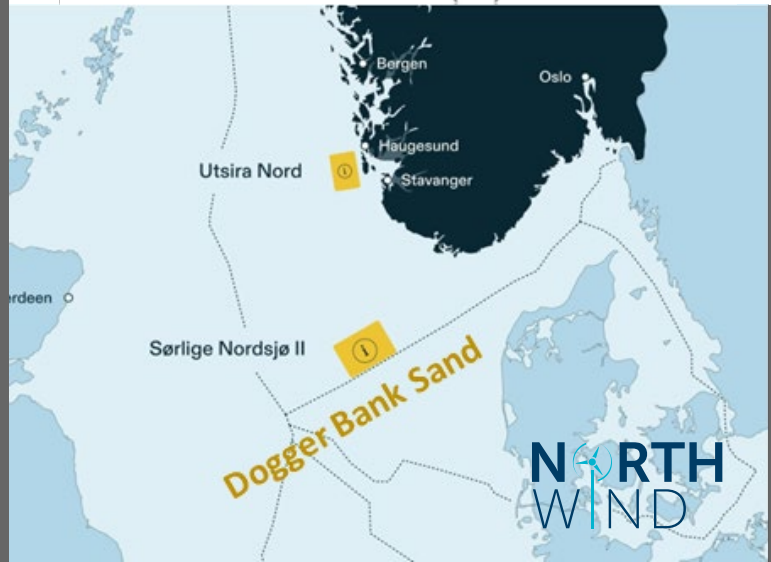


# Physical laboratory tests

- Dogger Bank sand chosen as representative from the North Sea
- Laboratory tests conducted over 10 years (Blaker and Andersen, 2015)



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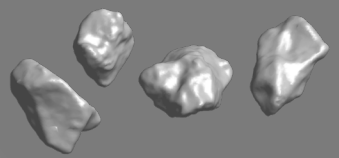

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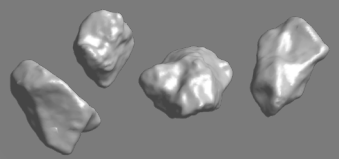

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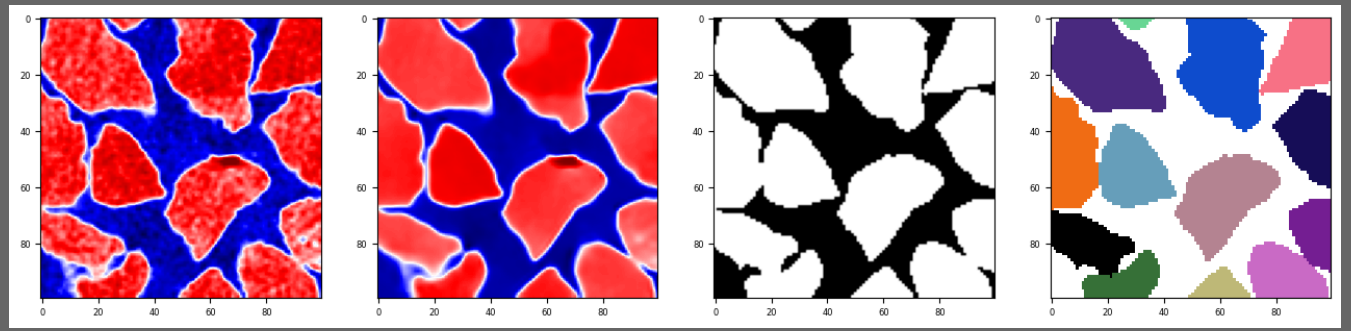
# Database of sand grains - accessing grain shape

- From X-ray Computed Tomography (XRCT) to «digital grains»

XRCT image

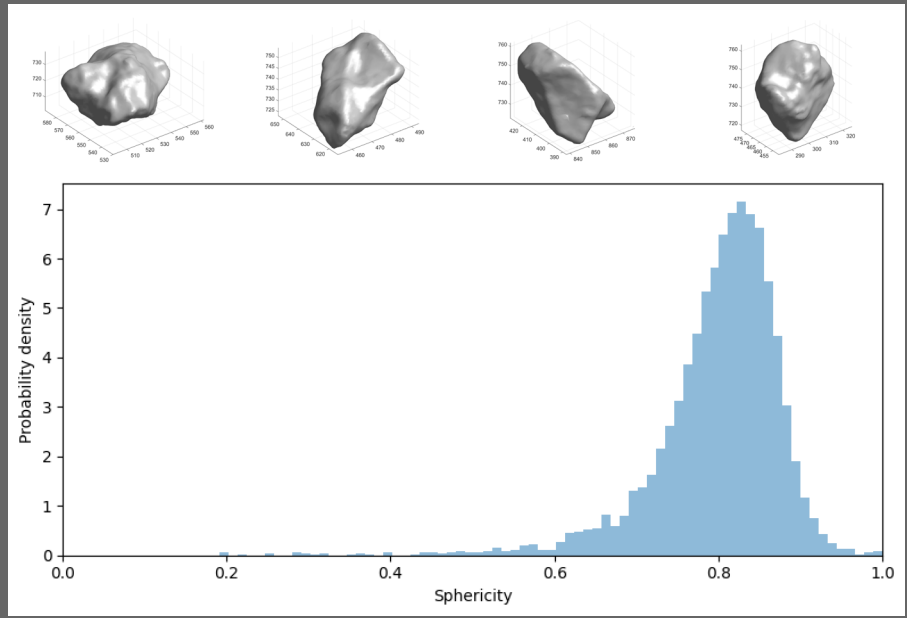
Filtered image
(de-noising)

Binarized image
(voids and solids)

Segmented image
(individual grains)

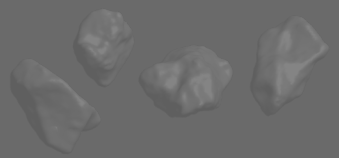
# Database of sand grains

- Sand grains currently in the database:
  - Doggerbank sand
  - Hokksund sand
  - Karlsruhe sand
  - Øysand
  - Ottawa sand



# The ingredients

Database of grains



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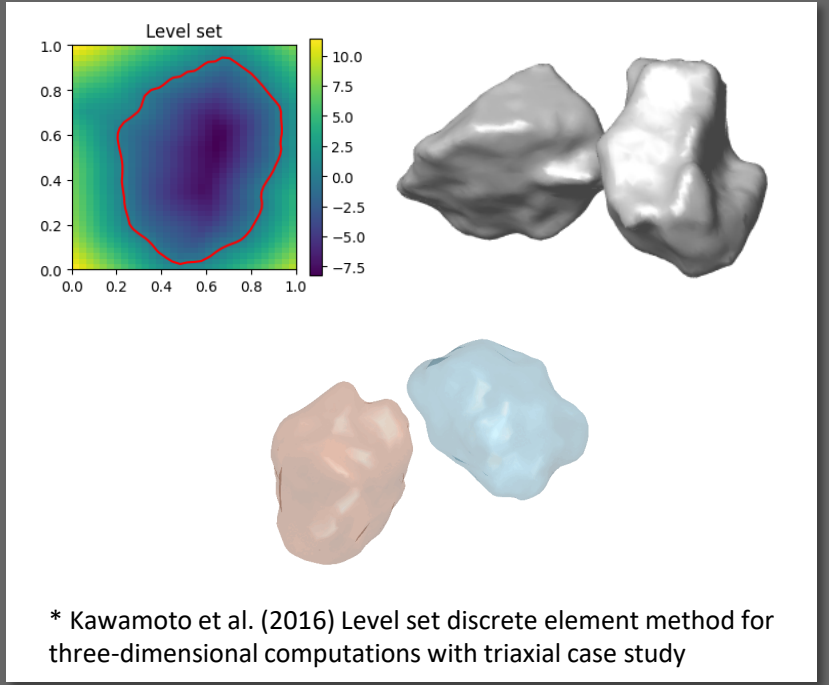
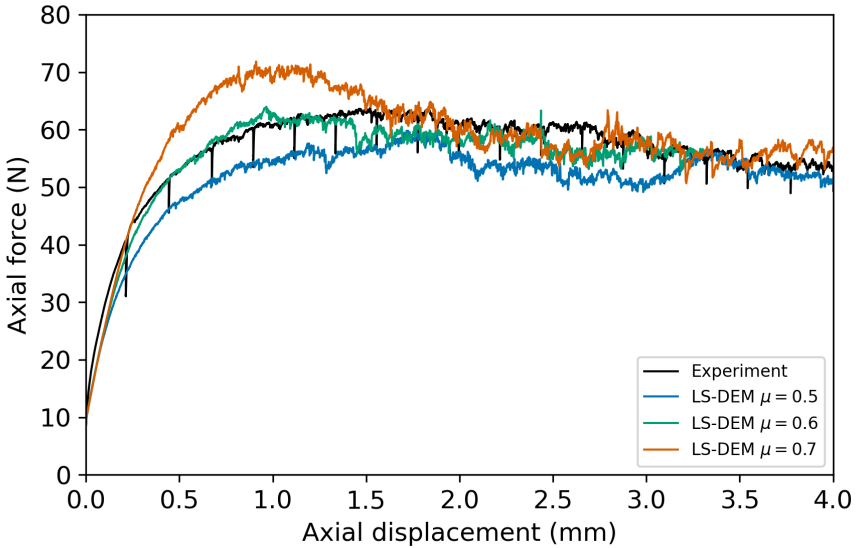
# Virtual tests – LS-DEM

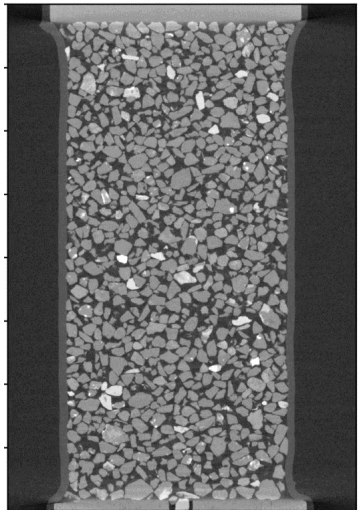
- Discrete rigid particles of arbitrary 3D shape described by level set functions
  - $\phi(p_{xyz})$: Level set
- Node-to-surface contact formulation
  - $K_n$ : Normal stiffness
  - $K_t$ : Tangential stiffness
  - $\mu$: Contact roughness (Coloumb friction model)
- Explicit time integration scheme

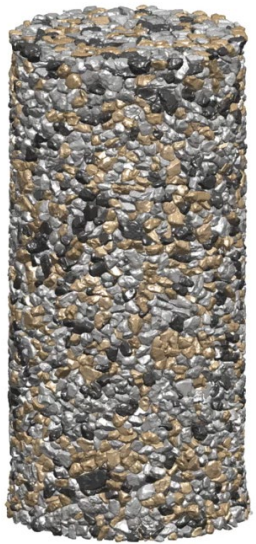



* Kawamoto et al. (2016) Level set discrete element method for three-dimensional computations with triaxial case study

# Comparison between physical and virtual tests

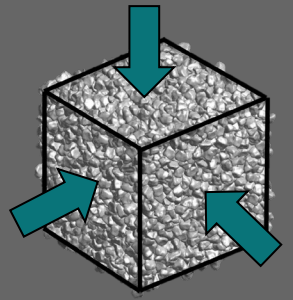




# Virtual lab

- We need “virtual” sand grains
- A tool to perform the simulations (LS-DEM)
- A user interface (dashboard)

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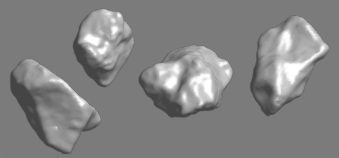

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Would you like to share your sand with us?

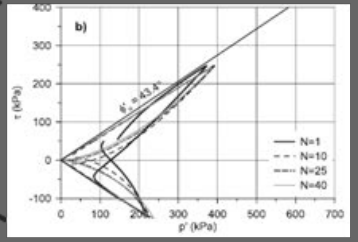
We welcome all types of sand – from Offshore sands in the North Sea to the sand you collect daily from your kids' shoes.

# API

Second step

VL-TEST-1 & PL-TEST-1

NorthWind Partner

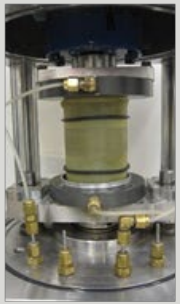



Physical Laboratory

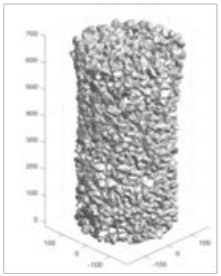
Sand Database API

Virtual Laboratory API

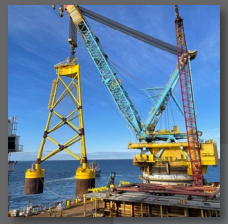
Database of grains



VL-TEST-1
VL-TEST-2
PL-TEST-1
PL-TEST-2
....

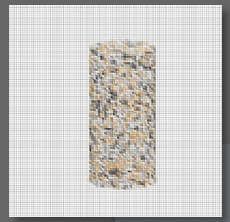


# What do we want to achieve with a database?



**For industry**

- Have soil data in early-phase design can help foundation concepts where Norwegian industry has an edge
- Reduce the required number of laboratory tests in projects



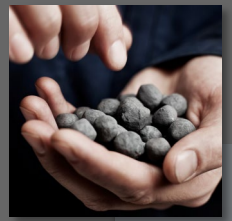
**For the research community**

- Gain better understanding of soil behaviour
- Have data to validate models
- Data sharing enhances cooperation between reseatch communities

# And with the virtual laboratory?

**For industry**

- Increase the current capacity for geotechnical testing of soils – lab capacity is a current bottleneck in the offshore wind supply chain



**For the research community**

- Develop a powerful tool for testing of granular material (no only sand, also gravel, or other granular materials like iron ore pellets)

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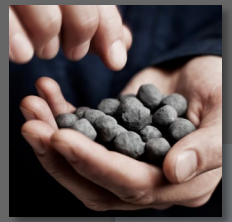

**community**

- Develop a powerful tool for testing of granular material (no only sand, also gravel,

**Combined:**

- Allow for non-traditional laboratory tests, or test that are difficult to achieve with existing hardware
- Accelerate the population of the database

#onsafeground

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