

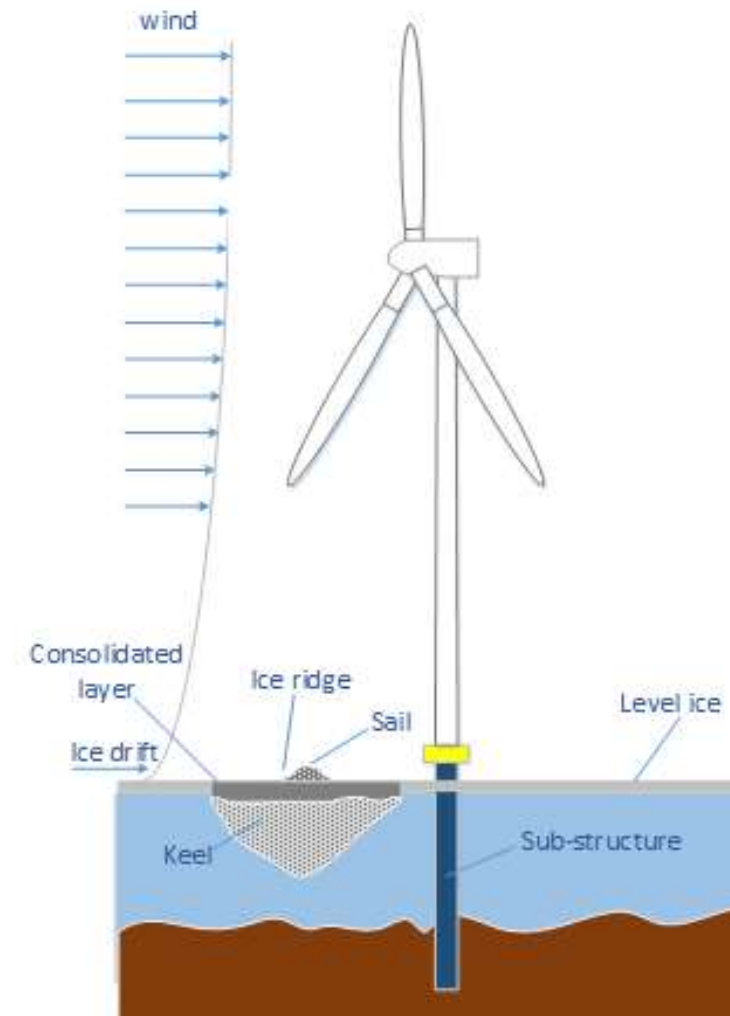
# **Development platform for the ice design of offshore wind turbines in the Gulf of Bothnia**

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## Structural design of offshore wind turbines in freezing sea areas

- Understanding how the offshore wind turbine structure behaves in ice interaction is crucial part of design in all freezing sea areas such as the entire Baltic Sea
- For the structural design, the following needs to be understood
  - Assessment of design sea ice conditions (what to expect during the structures lifetime)
  - Ice load methods for different sub-structure types
  - Modelling the structural behaviour under ice loading

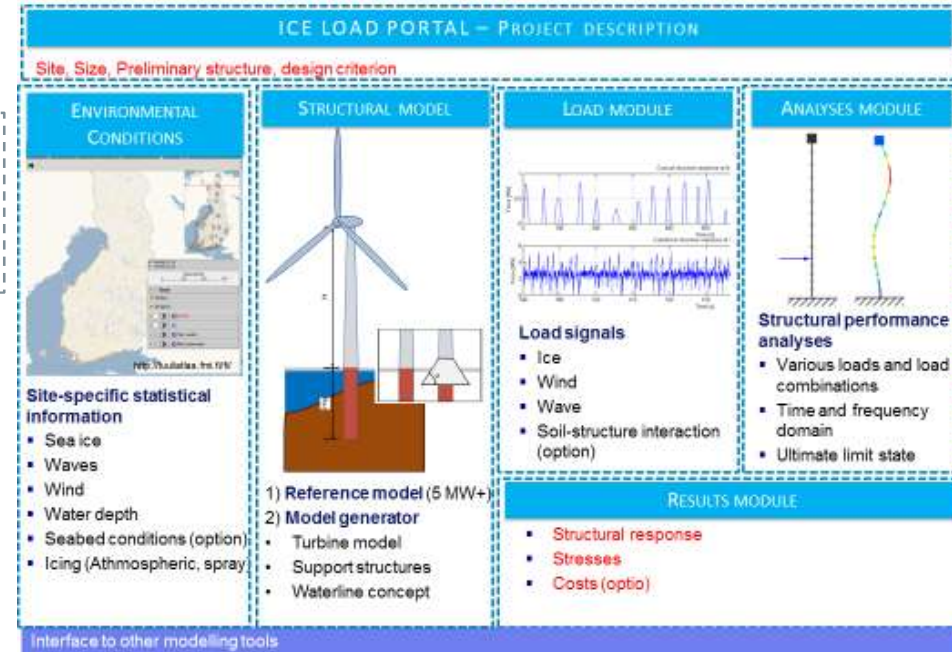


# Ice load design portal for offshore wind turbines

- Web user interface
- Aim to simplify the preliminary design of wind turbine / wind park
- All essential data and models are integrated within a single portal tool
  - Site-specific environmental conditions (GIS data)
  - Structures
  - Loads
- Rapid analysis: you'll get the results within couple of minutes
- Post-processing of results: the design criteria easily available
- Main challenge: Sea ice loads on support structures
- Focus area: Baltic sea, but can be later expanded to other sea areas
- Only license-free softwares are applied

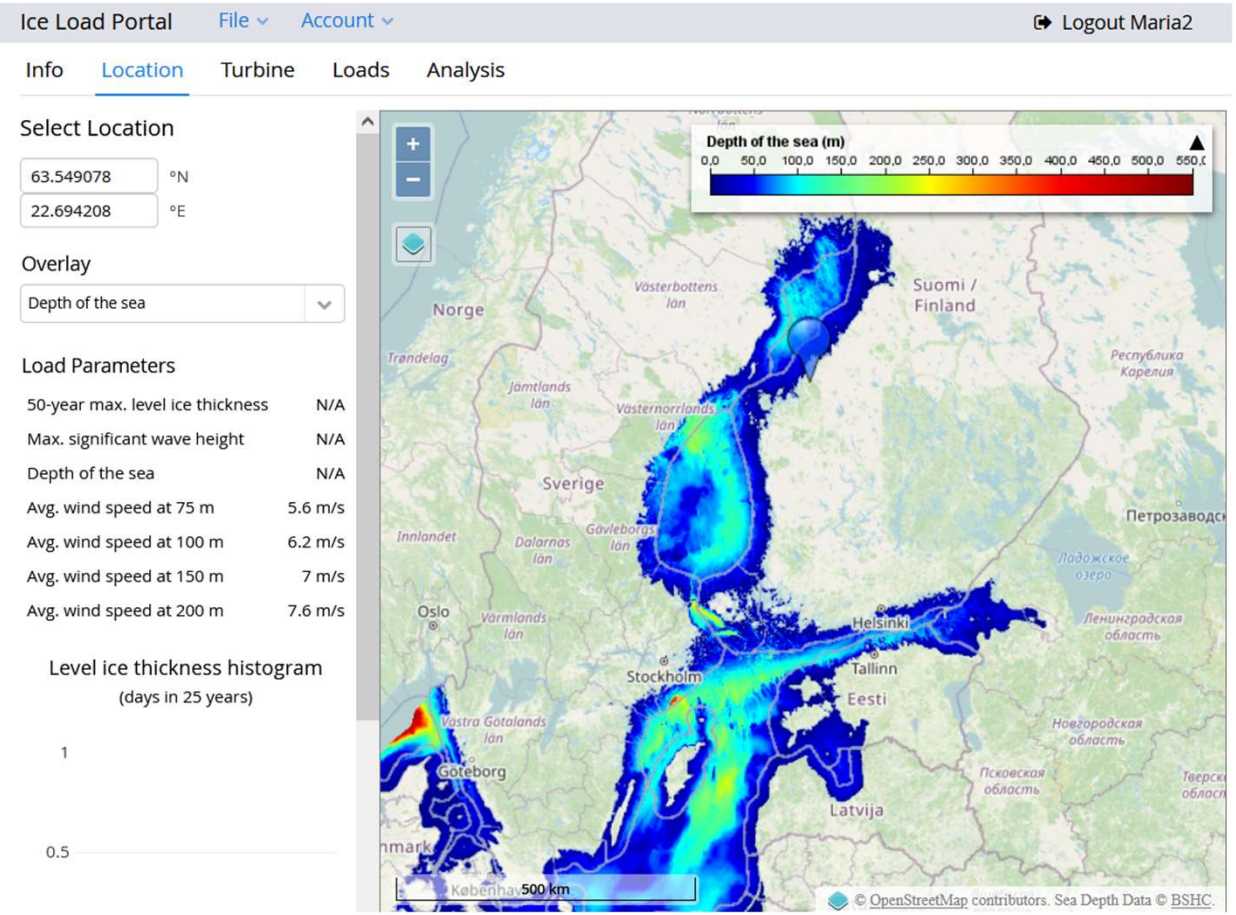
Ref.: J. Heinonen, M. Tikanmäki, J. Kurkela, P. Klinge, T. Hekkala, J. Koskela, A. Montonen, P. Eriksson:

Ice load design portal for sub-structures in offshore wind turbines in ice-covered sea areas.  
The 28th International Offshore and Polar Engineering Conference (ISOPE)



## Ice load portal speeds up the early-phase design

- All the data and models integrated into the same tool
- Speeds up the early design process
- Provides reliable input data for investment calculations
- Data of environmental conditions, structural models and loads can be further analyzed in other tools and applications when doing the final design
- Can be used as a development environment



# Environmental parameters

- Sea ice parameters
- Significant wave heights
- Depth of the sea
- Seabed substrates
- Wind speeds



# Sea ice design parameters

- Based on Finnish Meteorological Institute's digital and digitized ice charts from 1980/81-2021/22
- Site-specific design parameters for offshore wind turbine design calculated from the ice charts
  - 50-year maximum ice thickness
  - Ice thickness histogram
  - Ice type
  - Degree of ridging
- Unique database for design

Ice Load Portal [File](#) [Account](#) [Logout Maria2](#)

Info **Location** Turbine Loads Analysis

Select Location

64.842939 °N  
23.148437 °E

Overlay  
50-year maximum level ice thickness

Load Parameters

50-year max. level ice thickness	76 cm
Max. significant wave height	5.84 m
Depth of the sea	74 m
Avg. wind speed at 75 m	N/A
Avg. wind speed at 100 m	N/A
Avg. wind speed at 150 m	N/A
Avg. wind speed at 200 m	N/A

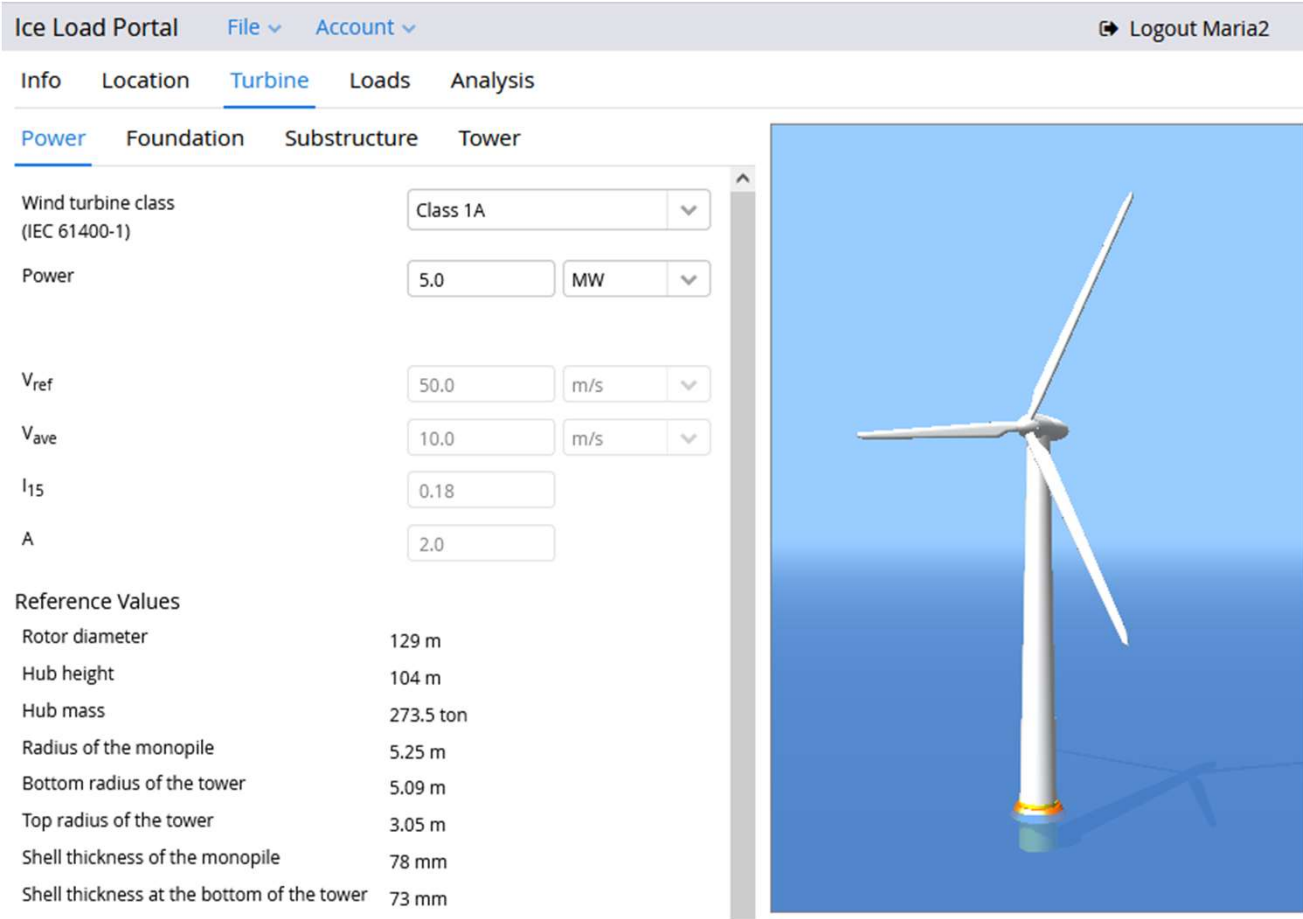
Level ice thickness histogram (days in 25 years)

Ice thickness (cm)	Days in 25 years
1-10	200
11-20	300
21-30	600
31-40	550
41-50	500
51-60	300
61-70	100
71-80	50
81-90	20
91-100	10
100+	5

Update Load Parameters

# Turbine and its parameters can be adjusted

- In the ice load design portal, different turbines can be chosen and the parameters related to it can be modified



The screenshot shows the 'Ice Load Portal' interface. At the top, there are navigation tabs: 'Info', 'Location', 'Turbine' (selected), 'Loads', and 'Analysis'. Below these are sub-tabs: 'Power', 'Foundation', 'Substructure', and 'Tower'. The 'Power' sub-tab is active, displaying the following configuration options:

- Wind turbine class (IEC 61400-1): Class 1A
- Power: 5.0 MW
- V<sub>ref</sub>: 50.0 m/s
- V<sub>ave</sub>: 10.0 m/s
- I<sub>15</sub>: 0.18
- A: 2.0

Below these are 'Reference Values' for various turbine components:

Parameter	Value
Rotor diameter	129 m
Hub height	104 m
Hub mass	273.5 ton
Radius of the monopile	5.25 m
Bottom radius of the tower	5.09 m
Top radius of the tower	3.05 m
Shell thickness of the monopile	78 mm
Shell thickness at the bottom of the tower	73 mm

On the right side of the interface, there is a 3D rendering of a white wind turbine with three blades, set against a blue sky and sea background.

# Several load models exist and can be combined in the portal

## Ice loads

### Level ice

- ISO19906 intermittent crushing
- IEC 61400-3 sinusoidal loading
- VTT Cone Model
- Sodhi model
- Määttänen-Blenkarn model

### Ice ridges

- Combined local vs. global load model
- Global failure (Croasdale's model)
- Local (Dolgoplov's model)

## Wind loads

IEC 61400-1 wind gust

IEC 61400-1 turbulence

Tower load

## Wave loads

Morison's load model

Nonlinear irregular wave load



# At the end, structural performance can be analysed

- After all the details are chosen, the structural performance can be analysed
- The portal can be used as a development environment
- Other load models can be added according to the needs

The screenshot displays the 'Ice Load Portal' software interface. At the top, there is a navigation bar with 'Ice Load Portal', 'File', and 'Account' menus. Below this is a secondary navigation bar with tabs for 'Info', 'Location', 'Turbine', 'Loads', and 'Analysis', with 'Analysis' being the active tab. The main content area shows 'Substructure: Monopile + Ice cone'. There are three dropdown menus for selecting load models: 'Ice load' is set to 'Level ice - VTT Cone model', 'Wind load' is set to 'EOG', and 'Wave load' is set to 'No'. Below these is a 'Show Advanced Options' toggle. At the bottom, there is a 'Simulate' button with a gear icon.

# Conclusions

- Ice load design portal speeds up the early development phase of offshore wind turbines by collecting all the data to same place
- It can be used as a development environment
- Historical ice charts were utilized to calculate site-specific design ice parameters
- Ice parameters are included in the ice load design portal together with other environmental parameters, structural models, load models, and analysis tool



# bey<sup>0</sup>nd

## the obvious

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