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

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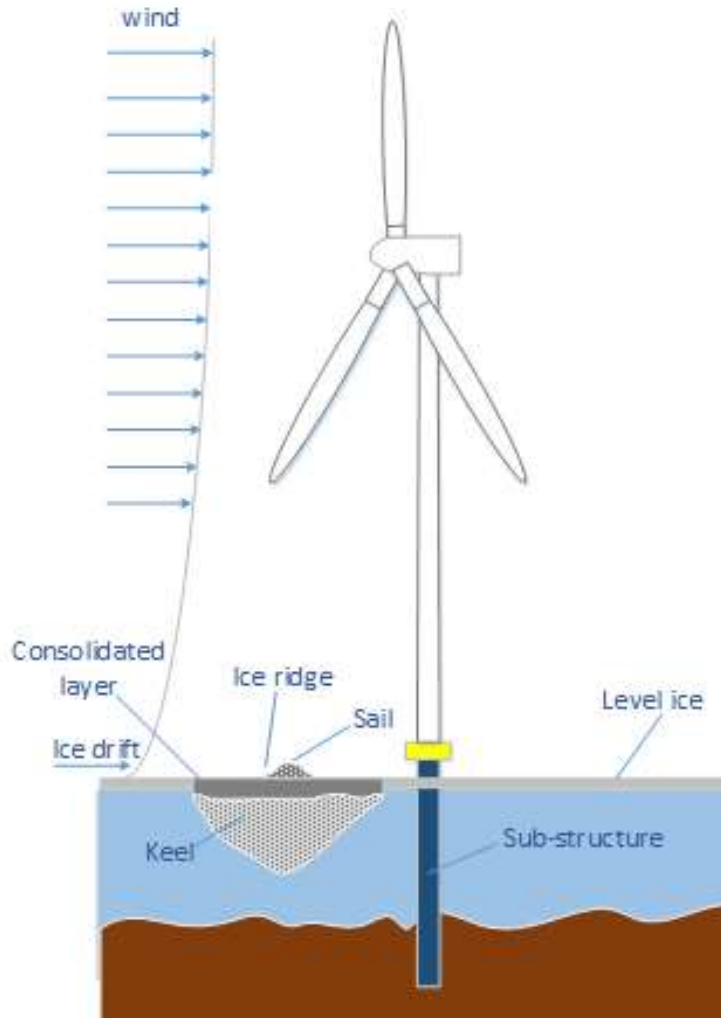
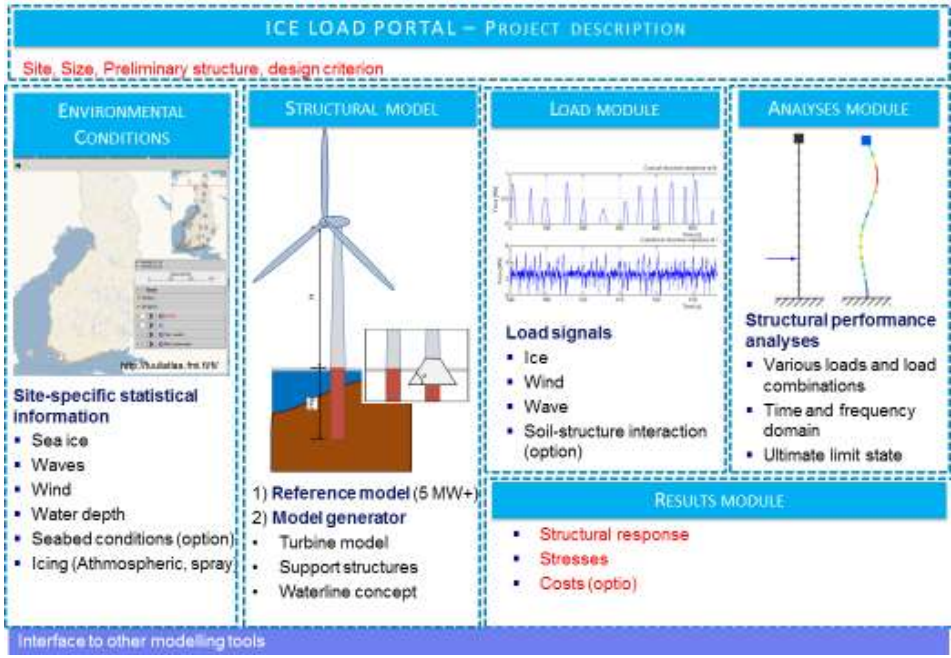
Structural design of offshore wind turbines in freezing sea areas

- 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

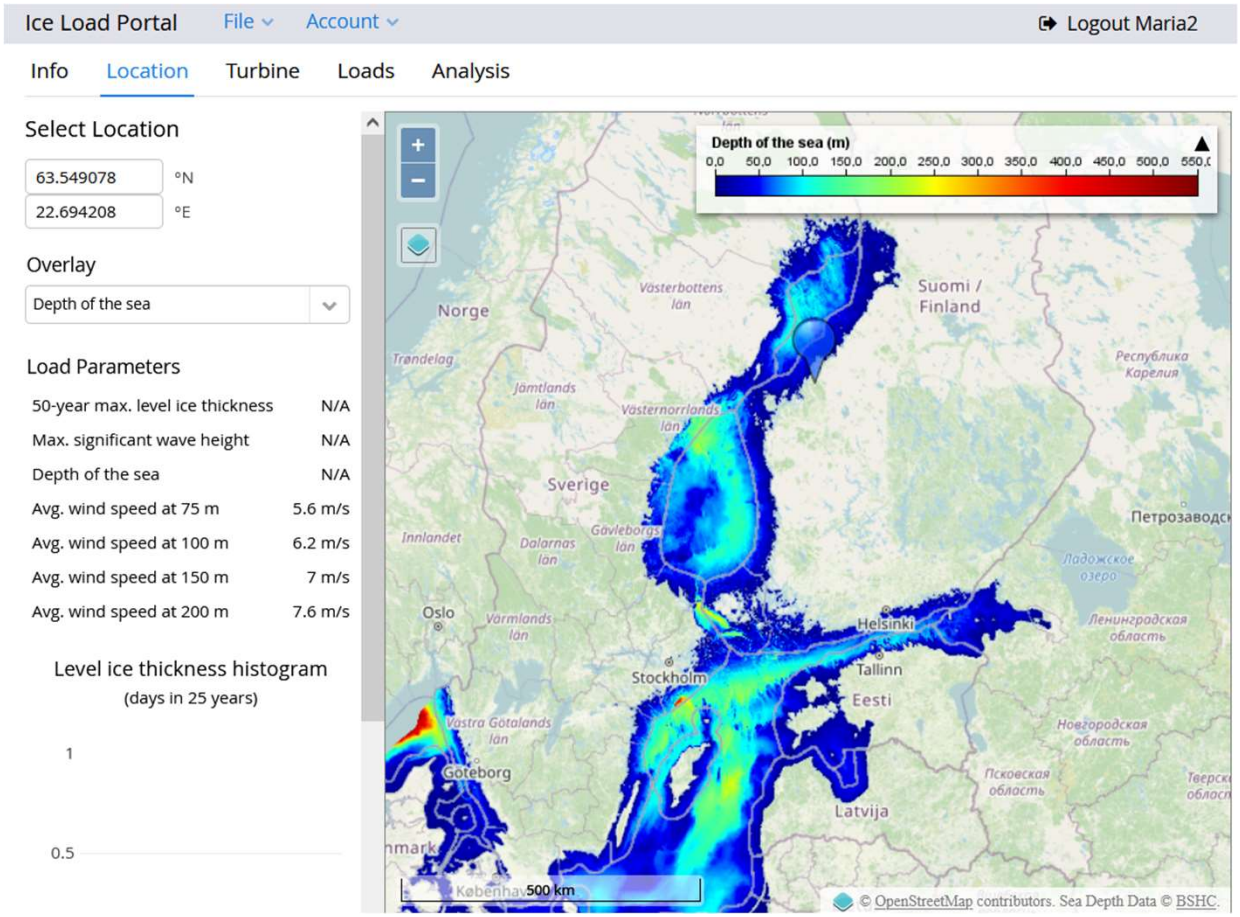
- Web user interface
- Aim to simplify the preliminary design of wind turbine / wind park
- All essential data and models are integrated within a single portal tool
  - Site-specific environmental conditions (GIS data)
  - Structures
  - Loads
- Rapid analysis: you'll get the results within couple of 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)

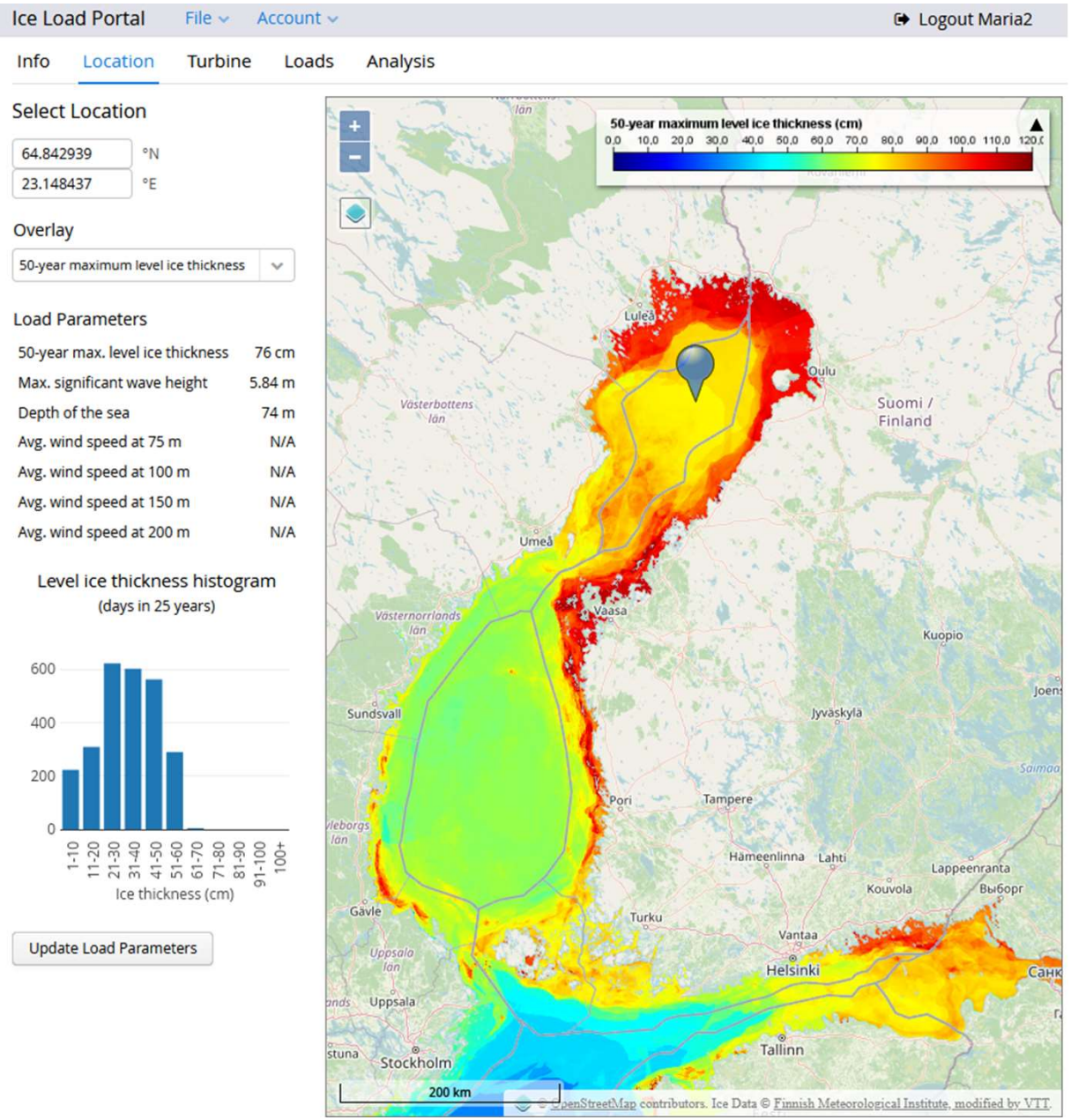
Ice load portal speeds up the early-phase design

- 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

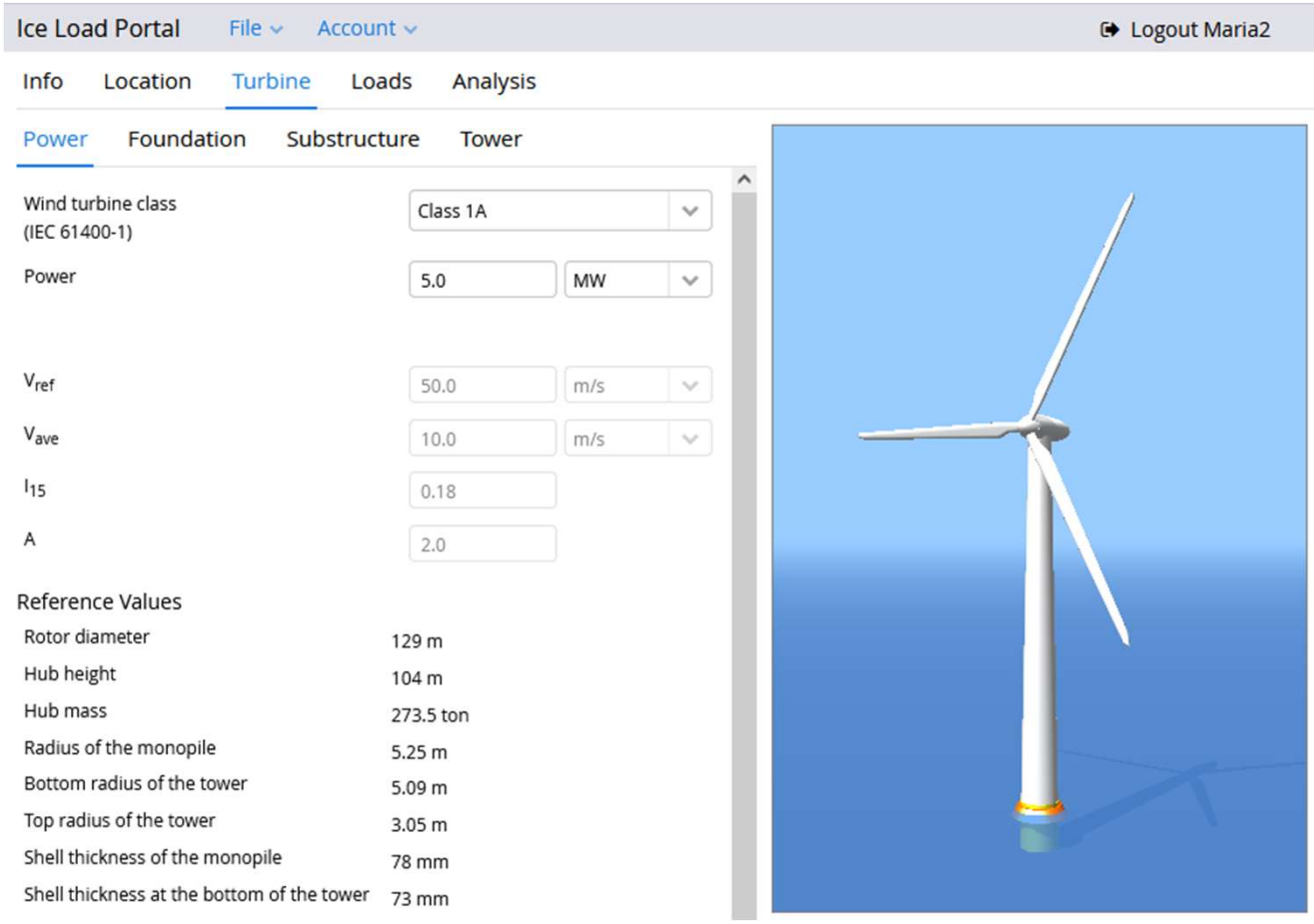


Sea ice design parameters

- Based on Finnish Meteorological Institute's digital and digitized ice charts from 1980/81-2021/22
- Site-spesific 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

Turbine and it’s parameters can be adjusted

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



Several load models exists 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 (Dolgopolov's model)

Wind loads

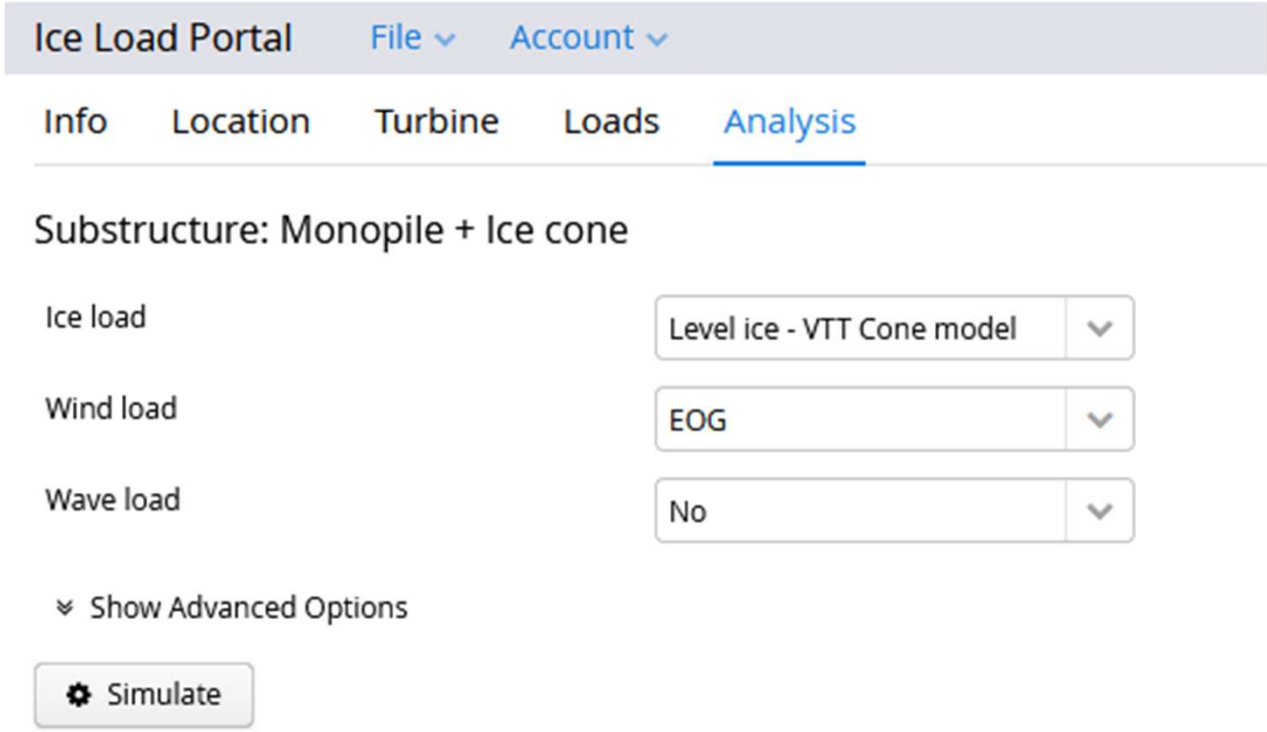
- IEC 61400-1 wind gust
- IEC 61400-1 turbulence
- Tower load

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



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

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the obvious

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