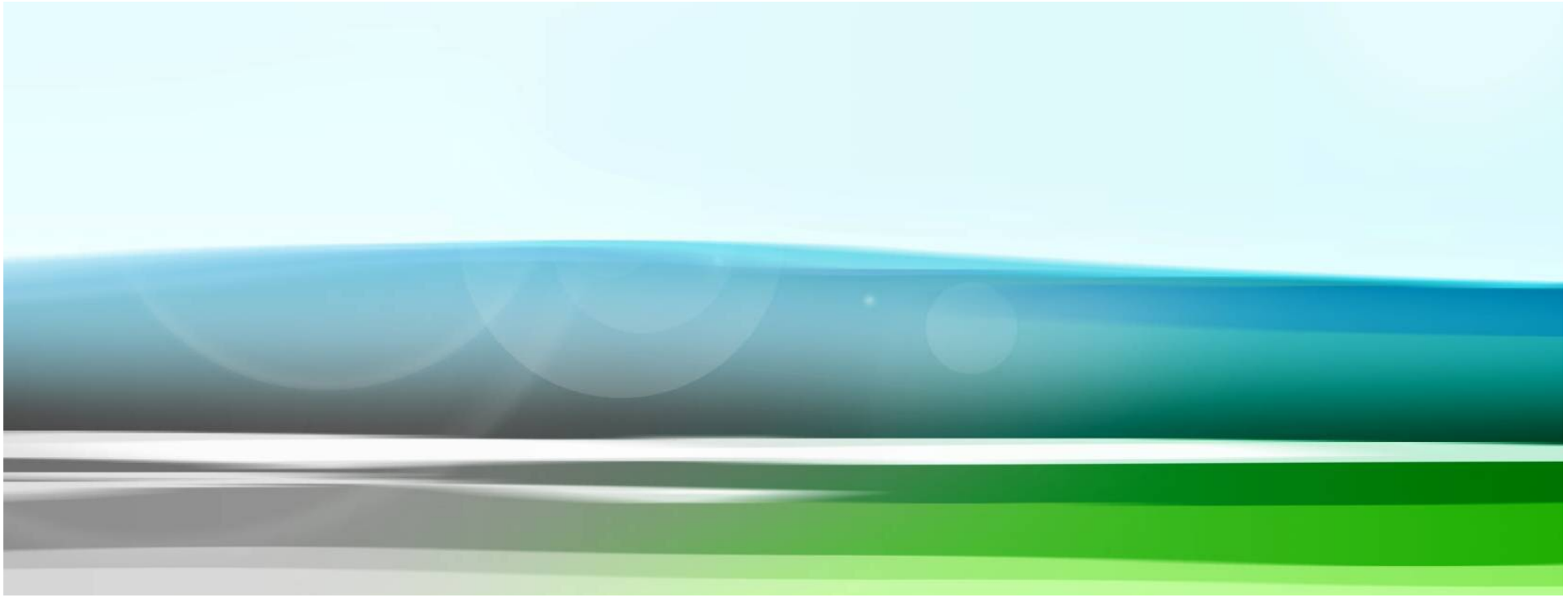


Adapting Engineered Structures to Climate Change

DNV ADAPT Framework

Nordic International Conference on Climate Change Adaptation, 29-31 August, Helsinki

Luca Garrè, Peter Friis-Hansen, Mark Trexler

MANAGING RISK DNV

Be Exposed or Adapt?

Power generation

Maritime operations

Infrastructure

Property/urban environments

Climate change exposes populations and assets to risks that will generate significant setbacks and losses

The challenge is:

- Is there a need for adaptation?
- What are we adapting to?
- How and when is adaptation appropriate?
- How can adaptation efforts go astray?

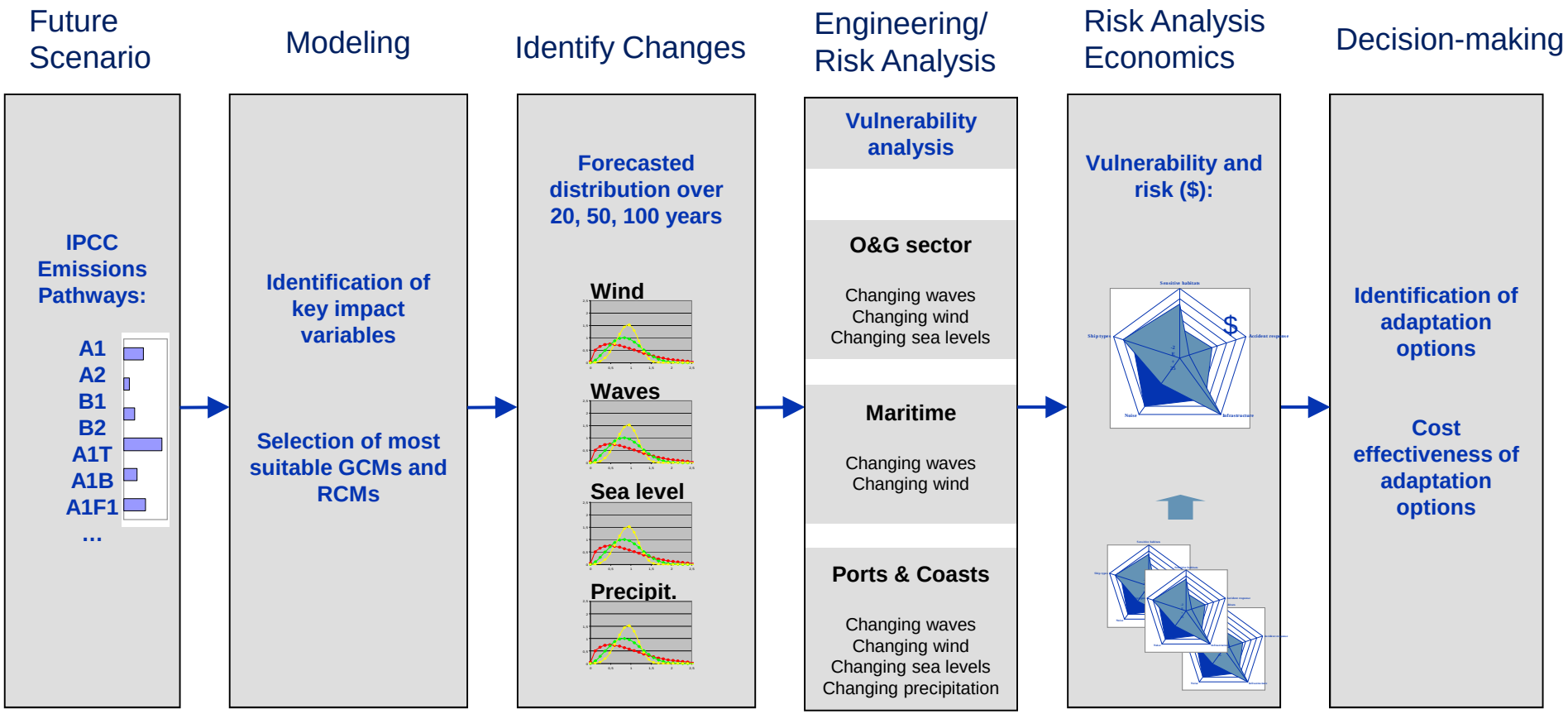
DNV ADAPT

Targeted Adaptation Decision-Making Should Be:

- **Based on reliable projections** of localized future climate risks over multiple timescales, e.g. 20-50-100 years
- **Based upon inter-disciplinary expertise**: climate modeling, engineering, and economics
- **Based on risk management** criteria
- **Transparency** in assumptions and results
- **Economically sound** and cost effective

DNV has embedded these principles into the DNV ADAPT framework for risk-based adaptation to climate change

DNV's ADAPT Framework



Actionable information for decision-makers

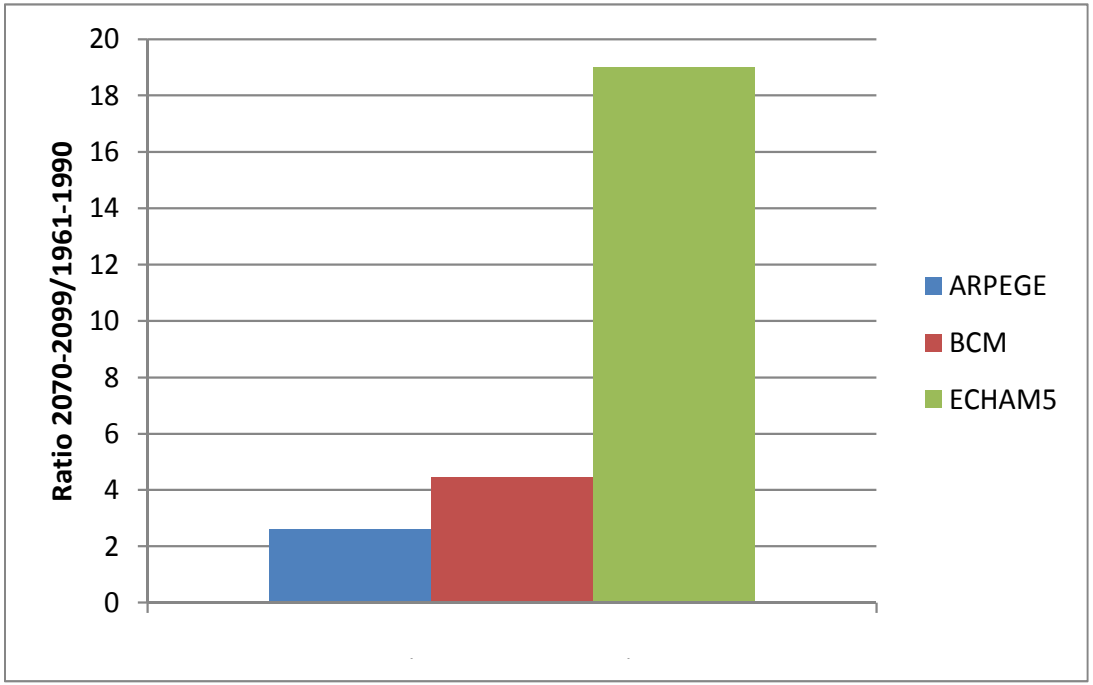
Outcome

Offshore Platform Case Study

- Climate models forecast atmospheric pressure changes that can be dynamically downscaled to estimate wind and wave changes
- Case study platform being designed for North Sea with 80 year lifetime
- Modelled consequences are wave in deck impact, and total loss of the platform
- What adaptive measures are called for in the design?

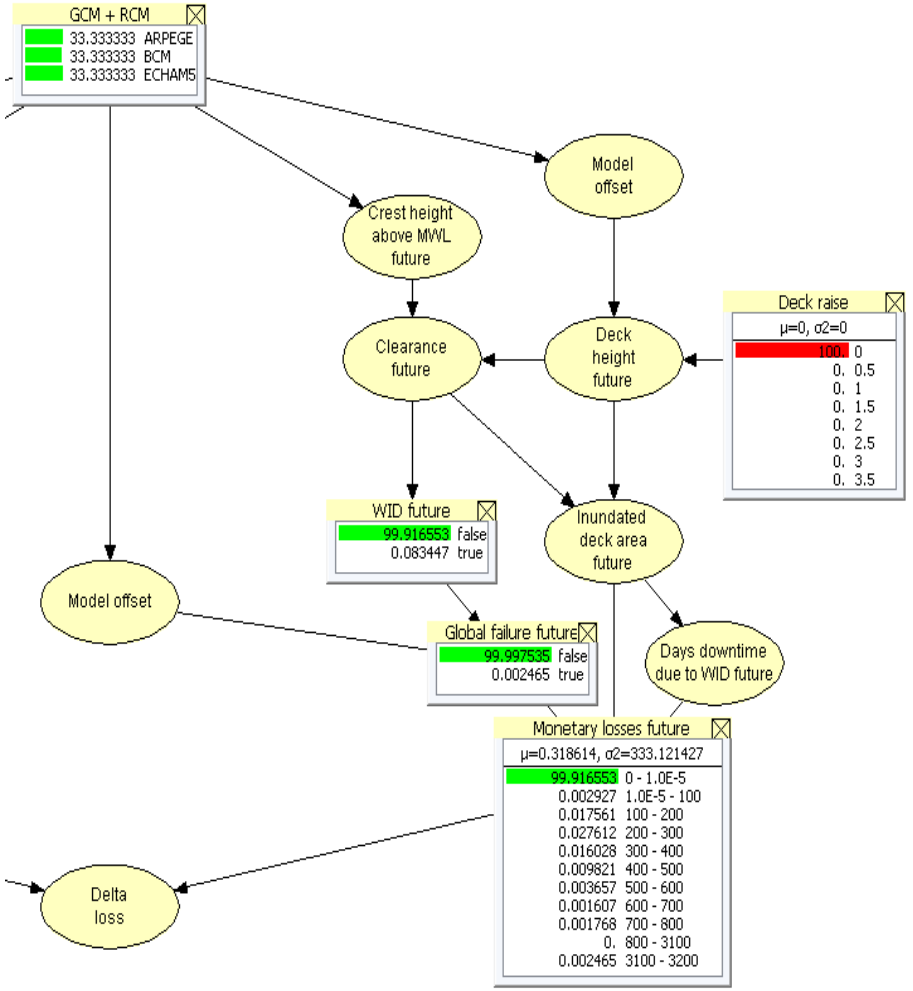
Future Wave Heights and Platform Safety

- Three model configurations:
  - ARPEGE + HIRAM5
  - BCM + HIRAM5
  - ECHAM5 + HIRAM5
- DHI's MIKE wave model
- Depending on the GCM, estimated frequency of wave-in-deck impacts increases by a factor of 2 to 18
- Depending on the GCM, frequency of total platform loss increases by factor of 1.5 to 2.5

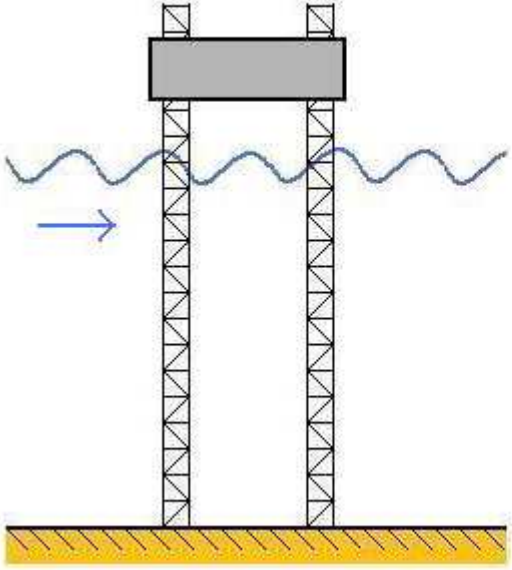


Risk and Economic Analysis

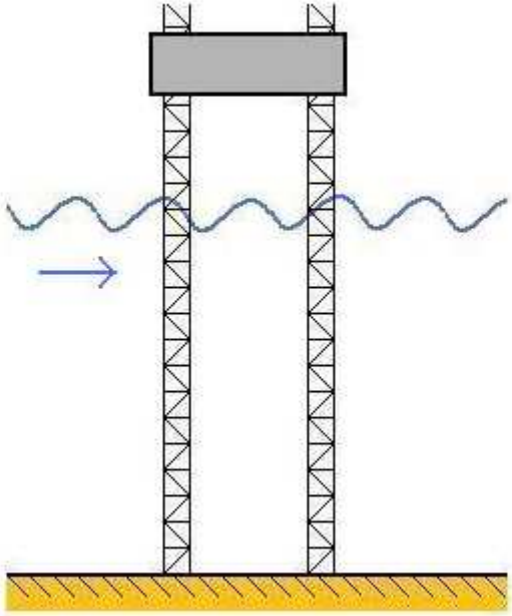
- Risk analysis performed with Bayesian Networks based on repair/replacement costs, deferred production, loss of reputation
- Risk assessed as the annual expected monetary loss (probability times consequences)
- Annualized risk estimate:
  - ~70,000 USD in present climate
  - >300,000 USD in future climate
- Total risk (no adaptation): ~$16 million



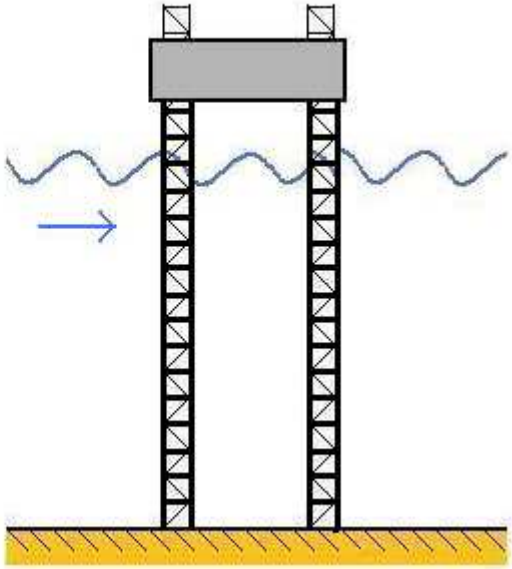
Adaptive Strategies



Base design

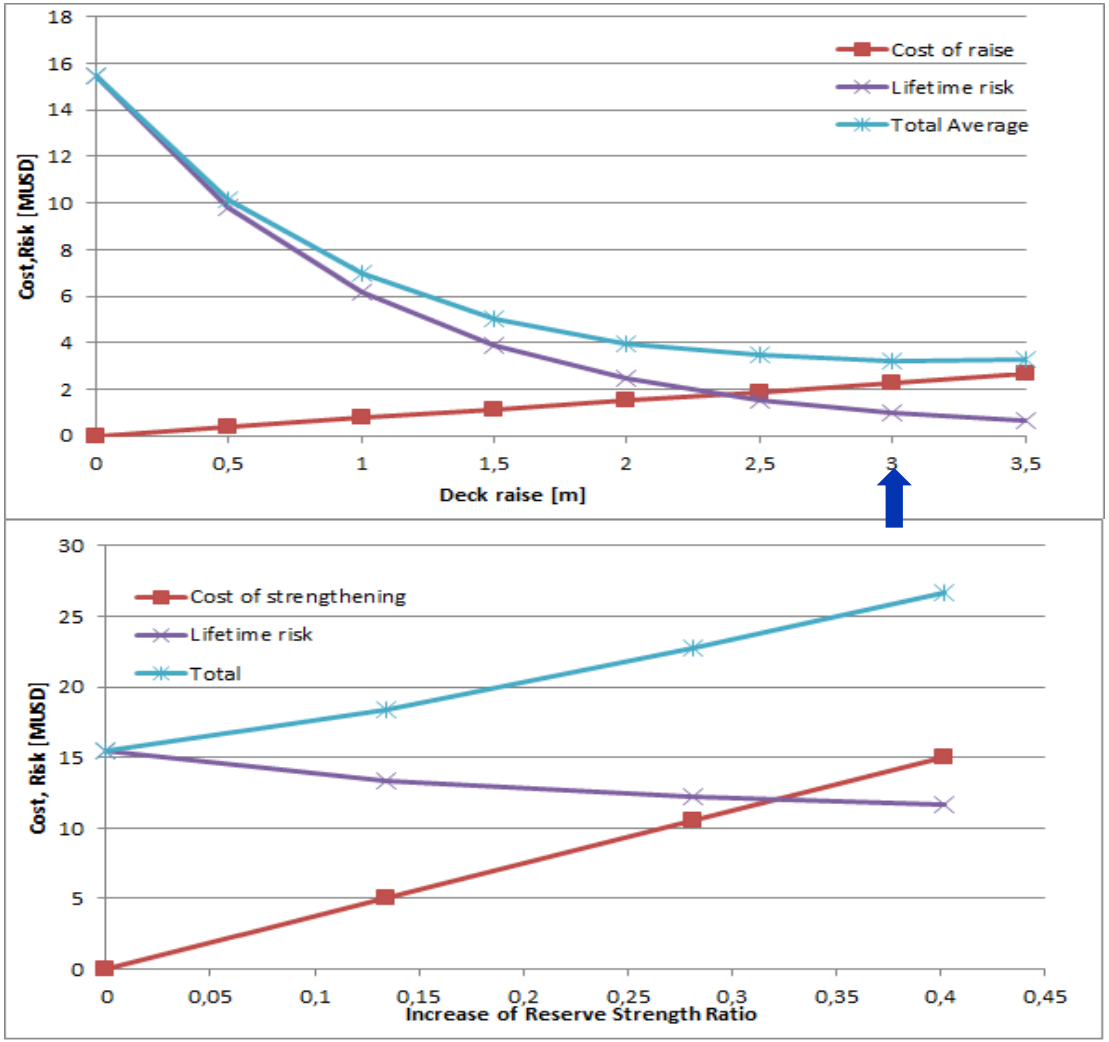


Deck raise



Strengthening of jacket

ADAPT Results



- Raising the deck is the most cost-effective adaptive strategy
  - 1–5 meter range, 3 meter average (RCM performance assessment may reduce uncertainty range)
  - Estimated cost of 3 meter raise is ~$3 MM, and reduces lifetime risk by ~$15 million
- Strengthening jacket is not recommended as cost-effective

Conclusions

- DNV ADAPT is a transparent decision-making framework that helps target cost effective adaptation measures
- DNV ADAPT can be used to evaluate adaptation measure robustness against different scenarios and model ensembles
- DNV ADAPT provides actionable information and outcomes in a context of high uncertainty
- DNV ADAPT Recommended Practice now being reviewed
- DNV ADAPT Case Studies currently being implemented:
  - Offshore platform (wave and wind)
  - Electric generation plant (water supply and temperature)
  - Offshore platform in the Arctic
  - Panama canal