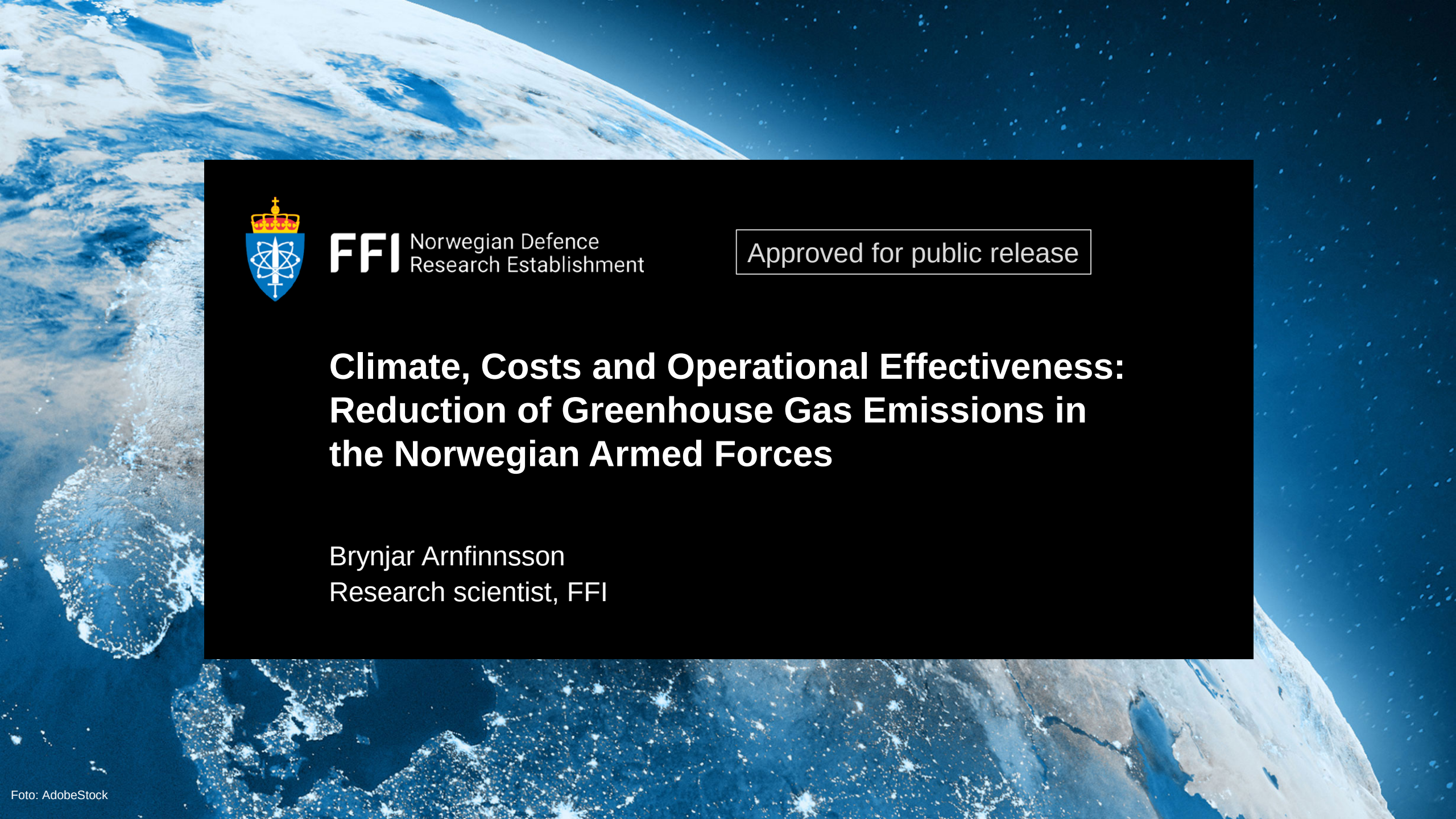

FFI Norwegian Defence Research Establishment

Approved for public release

Climate, Costs and Operational Effectiveness: Reduction of Greenhouse Gas Emissions in the Norwegian Armed Forces

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Agenda

1. Introduction
2. Analytical methods
3. Results
4. Conclusion

Introduction

- Climate change.
- Defence activities negatively effect the environment.
- Minimize negative effects while maintaining capability.
- Research question:
  - *How can the Norwegian Armed Forces reduce greenhouse gas emission, and maintain or improve capability? And at what cost or savings?*
- Delimitations (excluded from analysis):
  - Buildings, facilities and infrastructure.
  - Administrative vehicles.
  - Non-climate environmental effects.

Analytical methods

- Tool box:
  - Emission calculations.
  - Cost analysis.
  - Capability analysis.

- Stepwise approach:
  1. Establish a baseline for future emissions.
  2. Identify possible measures.
  3. Model effect of single measures.
  4. Modelling combined measures.

Step 1 – establish a baseline for future emissions

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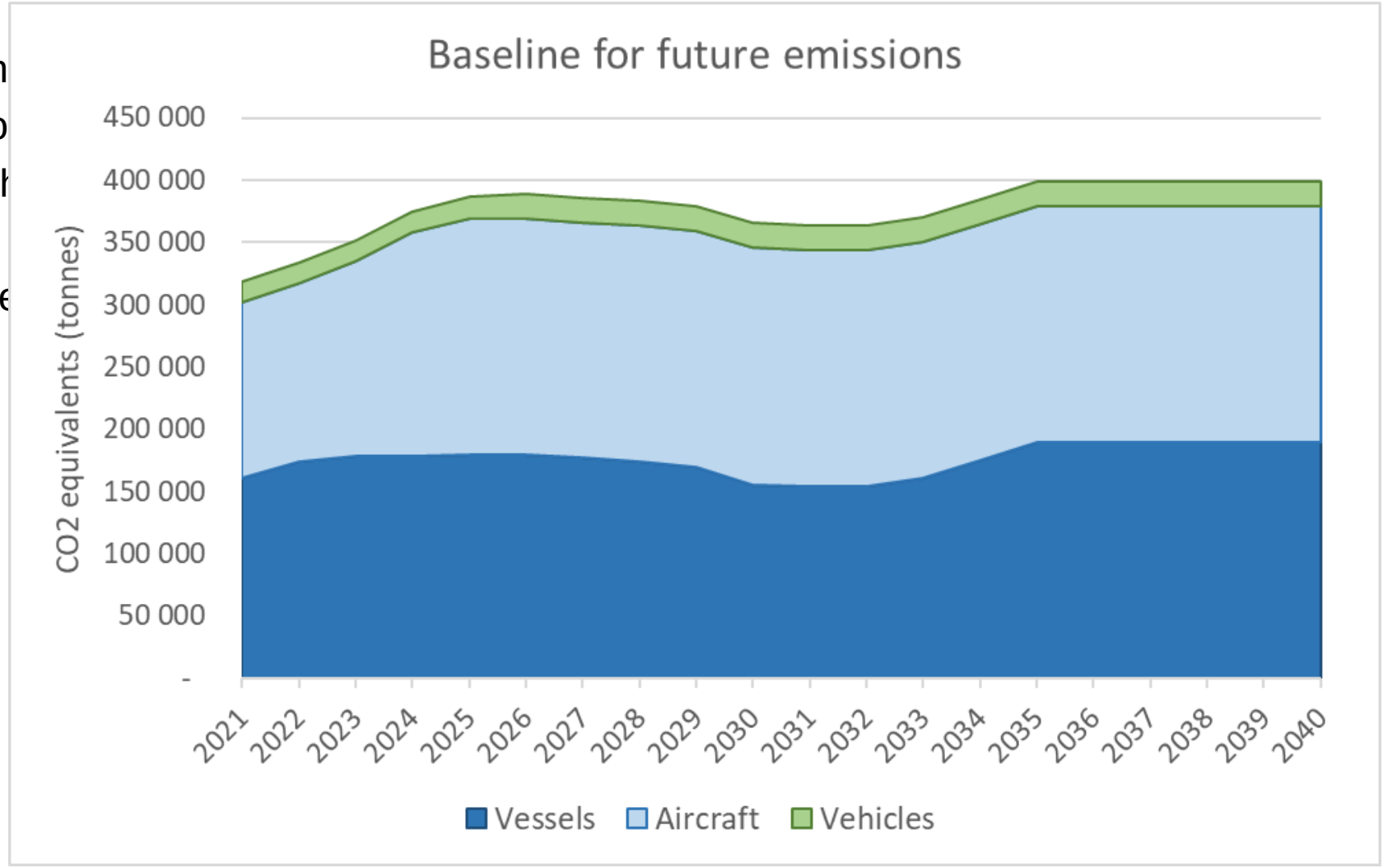


Step 2 – identify possible measures

- Brainstorming and literature review.
- Capability review.
- Selection process:
  - Will this measure negatively impact capability?
  - Will this measure/technology be eligible for application in the foreseeable future?
  - Is the infrastructure to support this measure/technology sufficient?
  - Can we quantify the emission reduction and cost of this measure?

Step 3 – modelling of single measures

- Standard cost analysis methodology.

- Emission reductions are modelled on a case-by-case basis.
  - Percentage reduction, or
  - Bottom-up modelling of emissions.
  - Life-cycle and indirect emissions included as far as possible.
  - Three-point estimates.

Step 4 – modelling of combined measures

- Avoid double counting of emission reduction.
- Incompatible measures.
  - Packages of compatible measures.
- Cumulative uncertainty.

Results

- Modelled measures:
  - Advanced biofuels.
  - Battery hybridization of surface vessels.
  - Energy efficiency measure of surface vessels.
  - Increased use of simulator systems.
  - An alternative replacement for the Nornen class Coast Guard vessels.
  - A new concept for maritime warfare.
  - Liquefied natural gas (LNG) on Coast Guard vessels.
- Other non-quantified measures:
  - Integrated environmental management
  - Green procurement practices
  - Reduction of food waste
  - Climate friendly food choices
  - Reduced (air) travel

Results: Measure 1 – Advanced biofuels

Description:

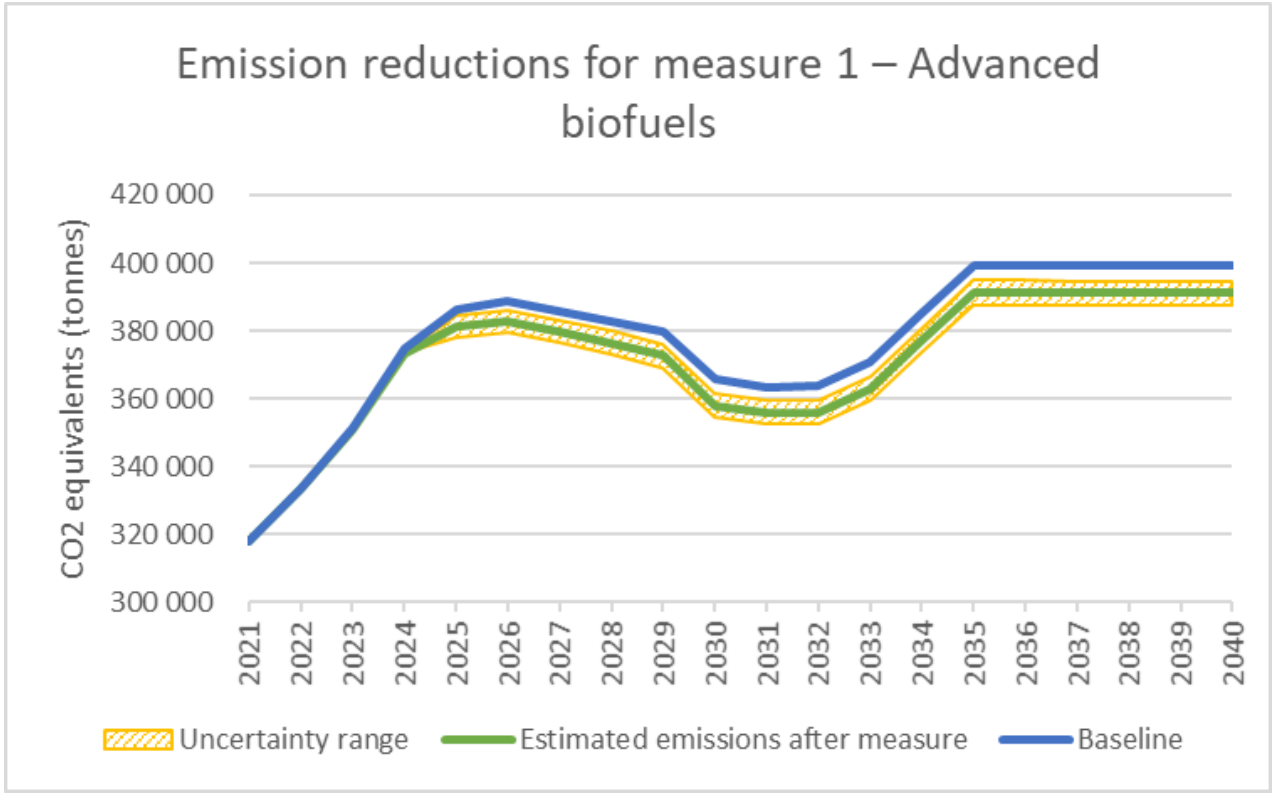
- Advanced biofuels added to the fuel mix.

Costs:

- 0.1–4 million € annually.

Summary:

- 4 000–11 000 tonnes CO_2-eq.s emission reduction.
- Many challenges regarding sustainability.
- Potential solution where there is no alternative to the internal combustion engine.



Results: Measure 2 – Battery hybridization of surface vessels

Description:

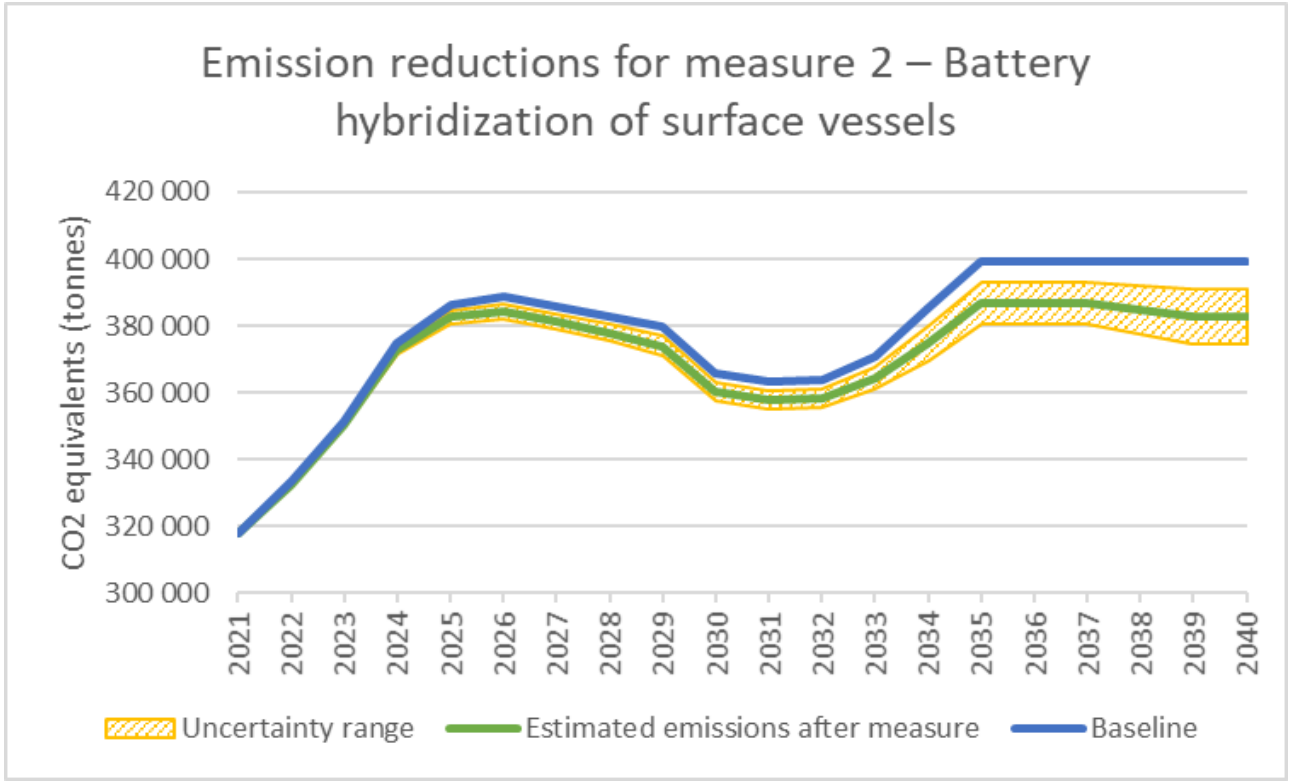
- Instalment of batteries on a range of suitable surface vessels during Mid-life update (MLU) or replacement.

Costs:

- Most likely cost-saving for certain vessels.
- Greater uncertainty for other vessels.
- Fast technological development.

Summary:

- 8 000–25 000 tonnes CO_2-eq.s emission reduction.
- Lower signature and greater range.



Results: Measure 3 – Energy efficiency measures on surface vessels

Description:

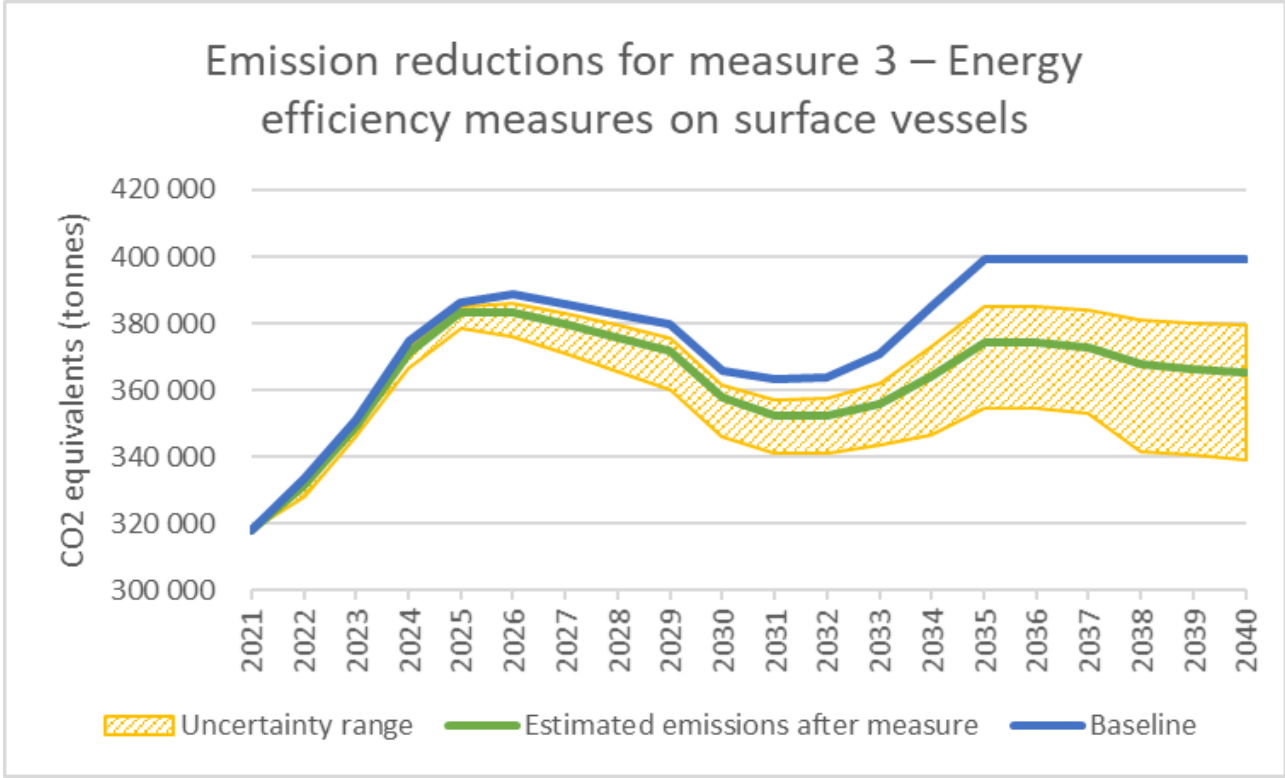
- Several energy efficiency measures grouped together.

Costs:

- Different costs and effects of the individual measures in this group.
- Many of the measures are assessed to be cost saving.

Summary:

- 19 000–60 000 tonnes CO_2-eq.s emission reduction.
- Lower signature and greater range.
- The individual measures needs to be considered in more detail.



Results: Measure 4 – Increased use of simulator systems

Description:

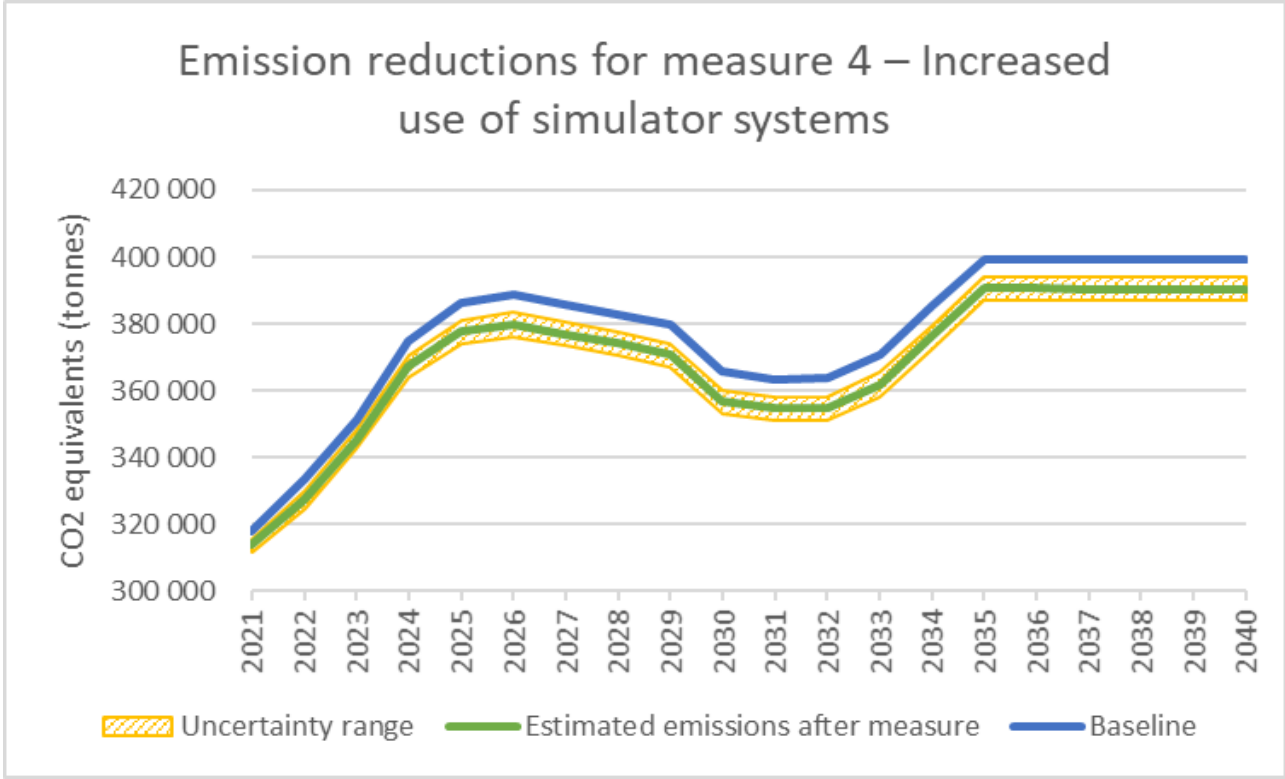
- Acquisition of full mission simulator systems for NH90 helicopters and P-8 maritime patrol aircrafts.
- Increased utilization of frigate simulator.

Costs:

- Very likely to be cost saving.

Summary:

- 5 000–12 500 tonnes CO_2-eq.s emission reduction.
- Positive effect on capability.



Results: Measure 5 – An alternative replacement for the Nornen class Coast Guard vessels

Description:

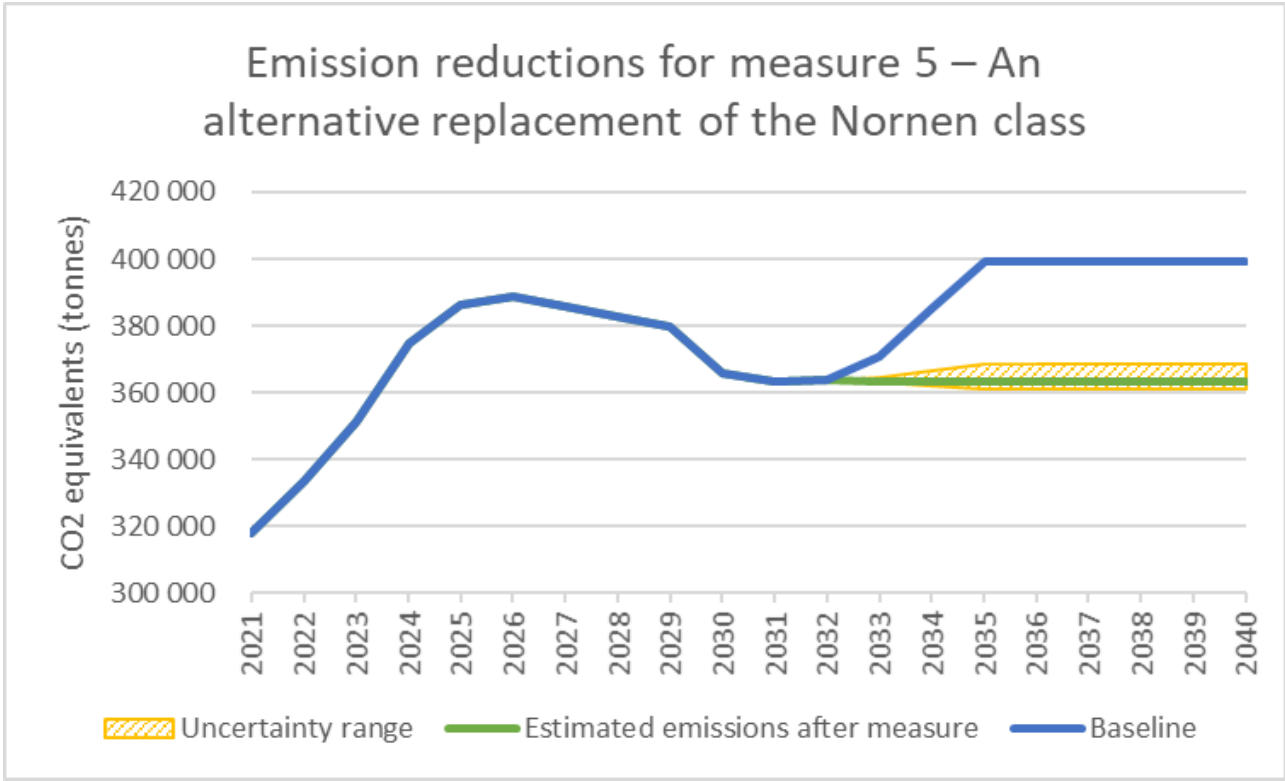
- Replace the Nornen class Coast Guard vessel with a new class of vessels roughly of the same size.

Costs:

- Cost-saving.

Summary:

- 30 000–38 000 tonnes CO_2-eq.s emission reduction.



Results: Measure 6 – A new concept for maritime warfare

Description:

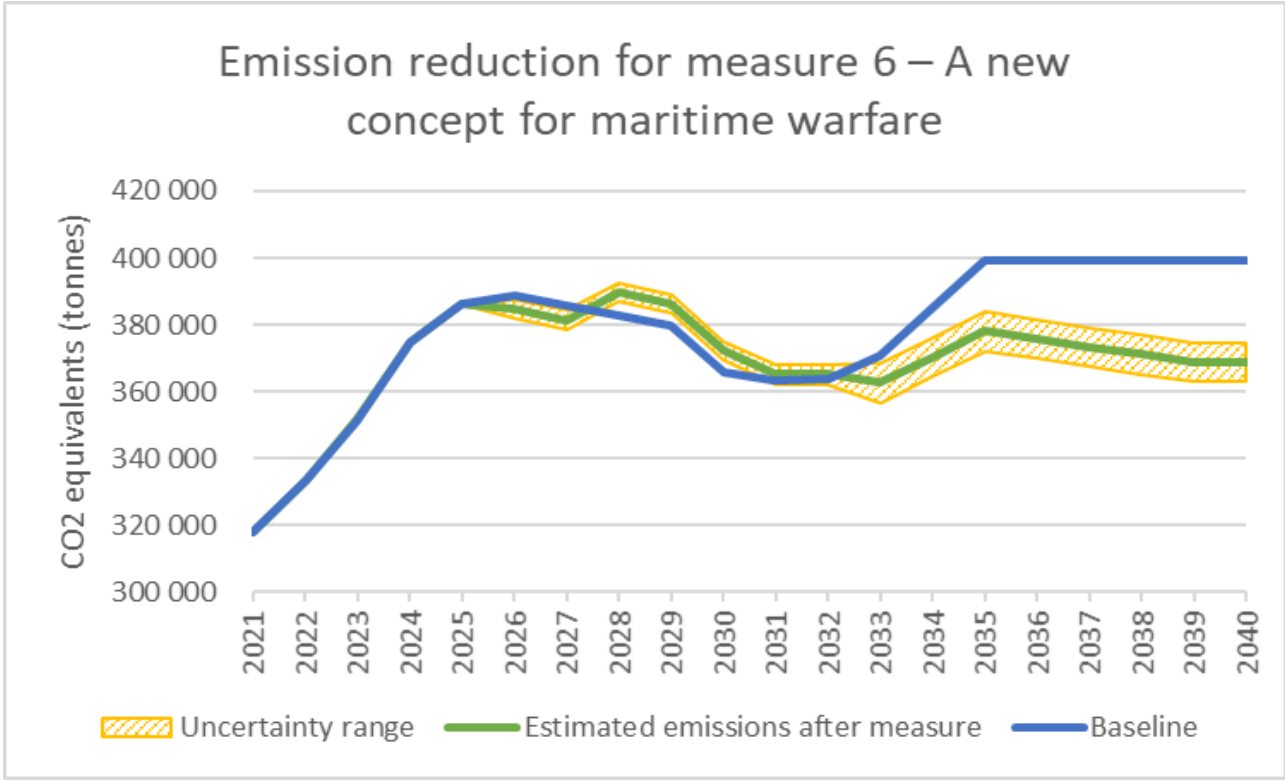
- Makes visible the climate effect of an alternative concept for maritime warfare, recently studied by Hansen and Dahlmo (2021).

Costs:

- Cost-saving.

Summary:

- 24 000–36 000 tonnes CO_2-eq.s emission reduction.
- Increased capability.



Results: Measure 7 – LNG on Coast Guard vessels

Description:

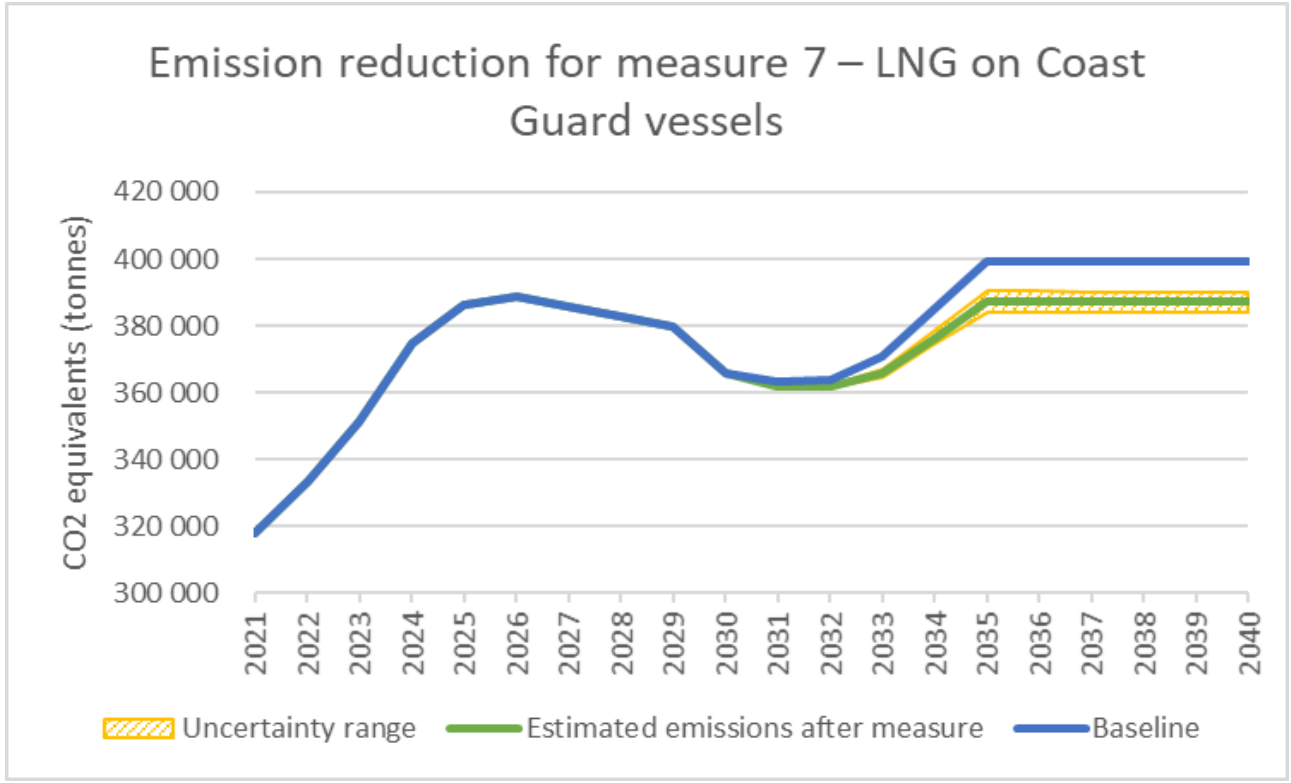
- LNG (liquefied natural gas) propulsion systems on new Coast Guard vessels.

Costs:

- Most likely cost saving.

Summary:

- 9 000–15 000 tonnes CO_2-eq.s emission reduction.
- Currently insufficient fuel infrastructure.
- Increased emission reduction in combination with liquefied biogas (LBG).



Results: Package of measures 1

Estimated total emission reduction:

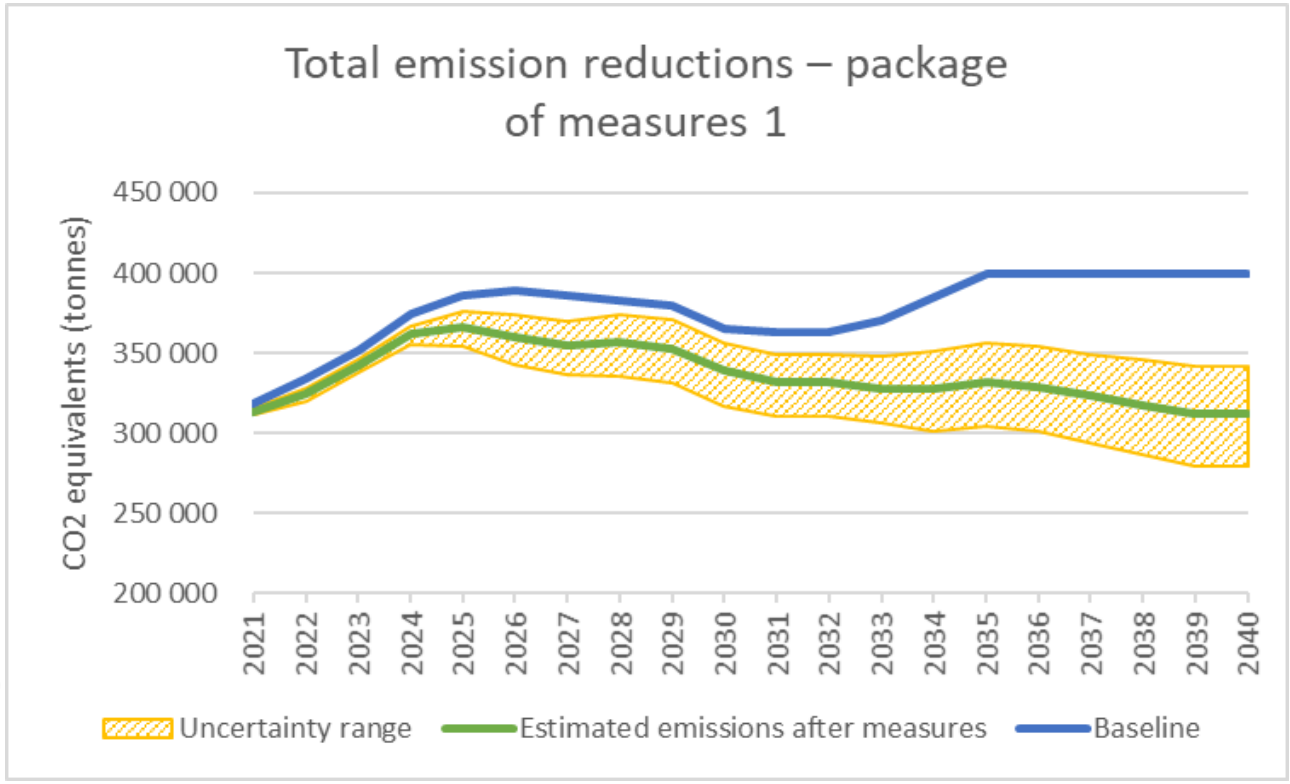
- 87 000 tonnes CO_2-eq.s, or
- 22 %.

Uncertainty:

- 58 000–120 000 tonnes CO_2-eq.s emission reduction, or
- 15–30 %.

Costs:

- Most reductions from measures that are likely to be cost-saving.
- Only biofuels are expected to increase costs.



Results: Package of measures 2

Estimated total emission reduction:

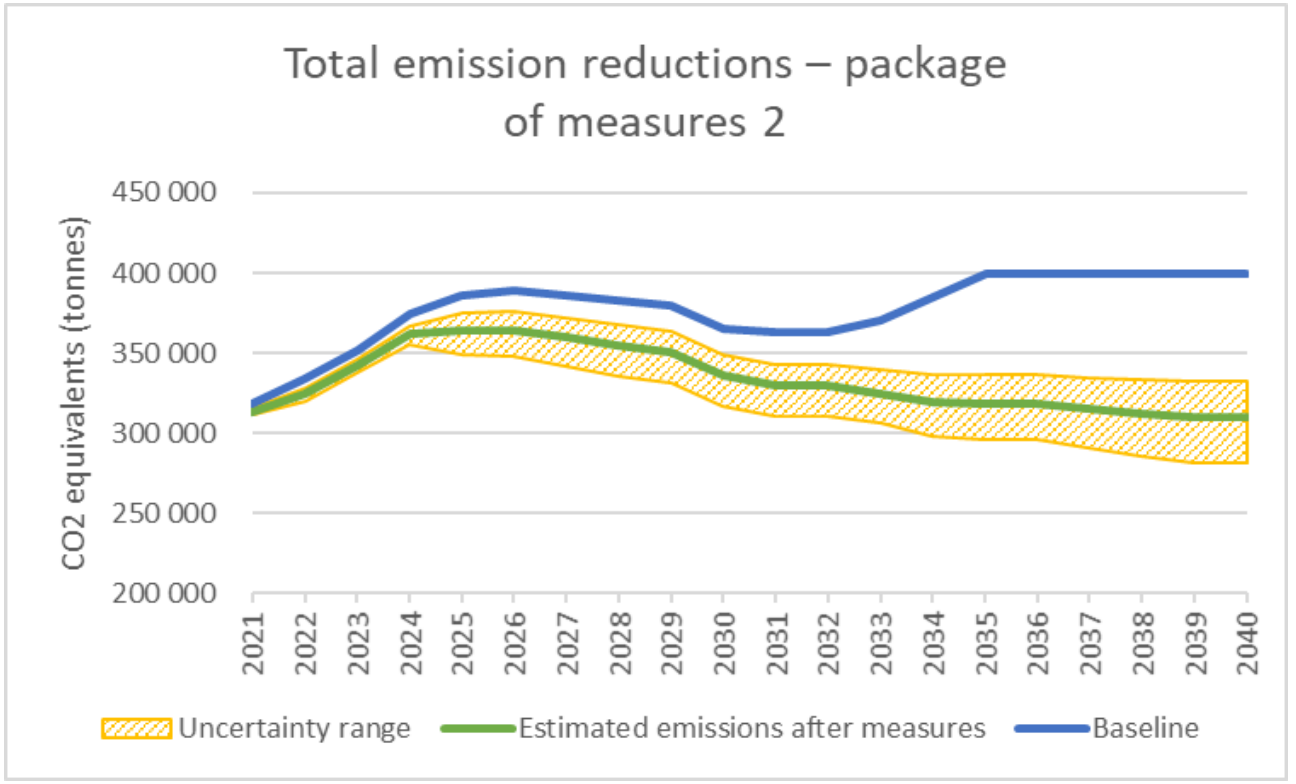
- 89 000 tonnes CO_2-eq.s, or
- 22 %.

Uncertainty:

- 67 000–118 000 tonnes CO_2-eq.s emission reduction, or
- 17–30 %.

Costs:

- Most reductions from measures that are likely to be cost-saving.
- Only biofuels are expected to increase costs.



Discussion of results

- Baseline: 25 % increase.
- Both packages reduces emissions to roughly todays level.
- Alternatives to the internal combustion engine.
- Biofuels and sustainability.

Conclusion

- Increase costs:
  - Advanced biofuels.

- Possibly or likely to be cost-saving:
  - Battery hybridization.
  - Energy efficiency measures on surface vessels.
  - Use of simulator systems.
  - An alternative replacement of the Nornen class Coast Guard vessels.
  - A new concept for maritime warfare.
  - LNG Coast Guard vessels.

- Most of these measures will increase capability.

Conclusion

- Military platforms have a long service life.
  - Decisions today generate emissions and costs for many years into the future.

- We recommend that emission projections gains a more prominent role in procurement decisions and the long-term planning process.

- Indirect emissions from the defence sector are substantial.
  - The non-quantified measures are equally important.
  - Balance effort targeting direct and indirect emissions.

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