Demonstration of fuel saving potential with WASP sea trials

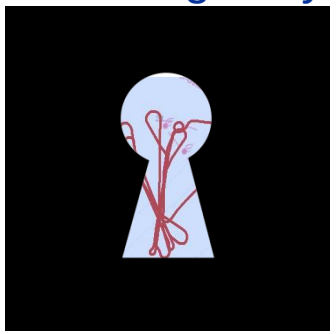
Frederik Gerhardt, Sofia Werner, SSPA Sweden AB, Sweden

WASP Sea trials

The challenge

Trial

Peek trough keyhole



- Short trial (minutes/hours)
- 1 ship speed
- Ca. 3-5 wind angles
- One wind and wave condition

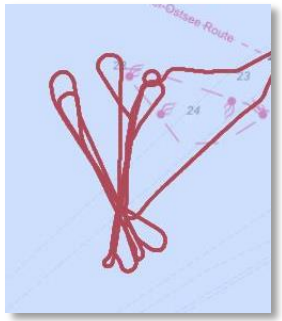
Ship in operation

Full Picture

- Annual fuel savings
- On actual route
- Range of ship speeds
- Actual trading pattern
- Consider wind statistics of operational areas

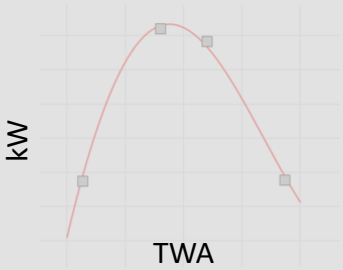
Method

1. Speed trial



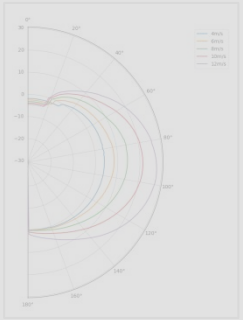
2. Analyse speed trial

Power saving 1 wind speed



3. Calibrate virtual ship model

Power saving at any wind condition



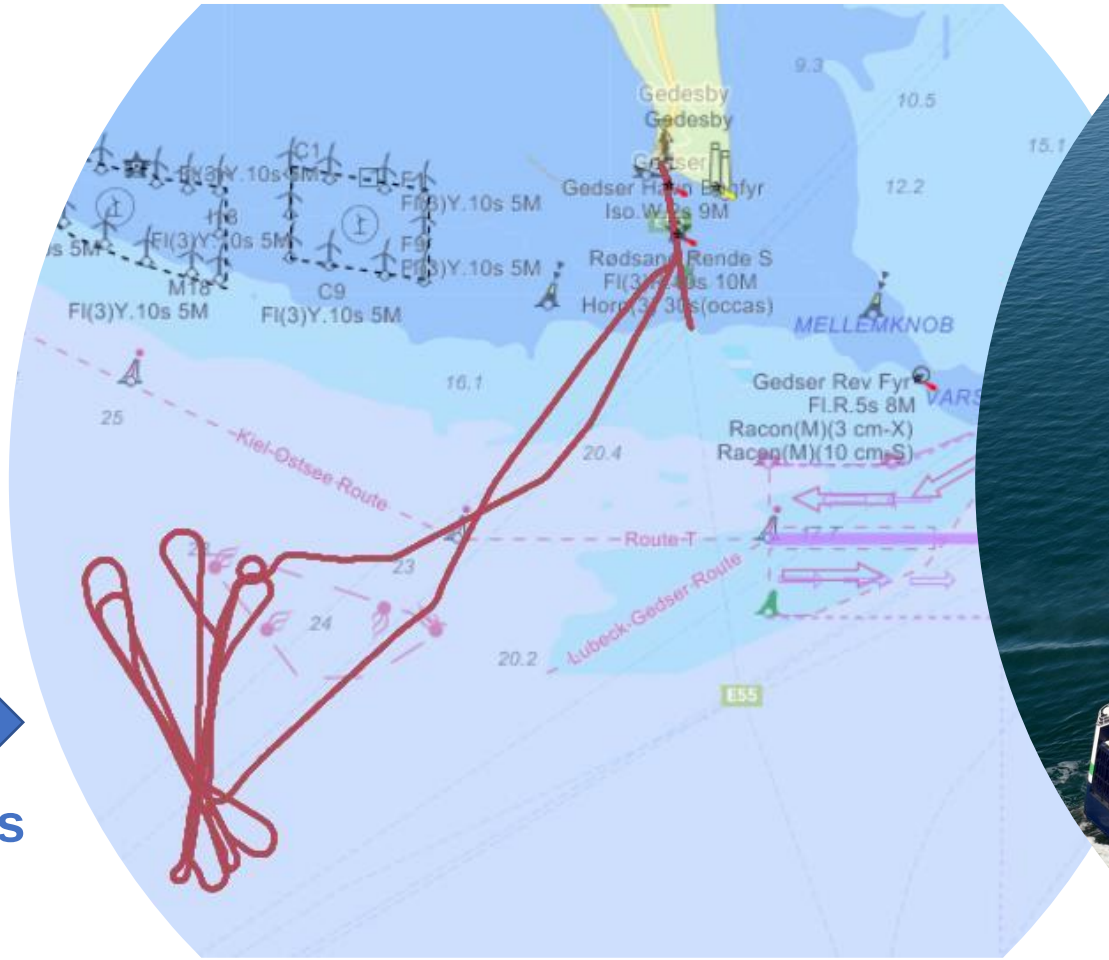
4. Voyage analysis

Average fuel saving

Full scale trials in WASP

- Main objective: to confirm fuel saving (not ranking of WPTs !)
- Test methodology: Compare with and without WPT
- All devices in WASP can be turn off/on or be tilted

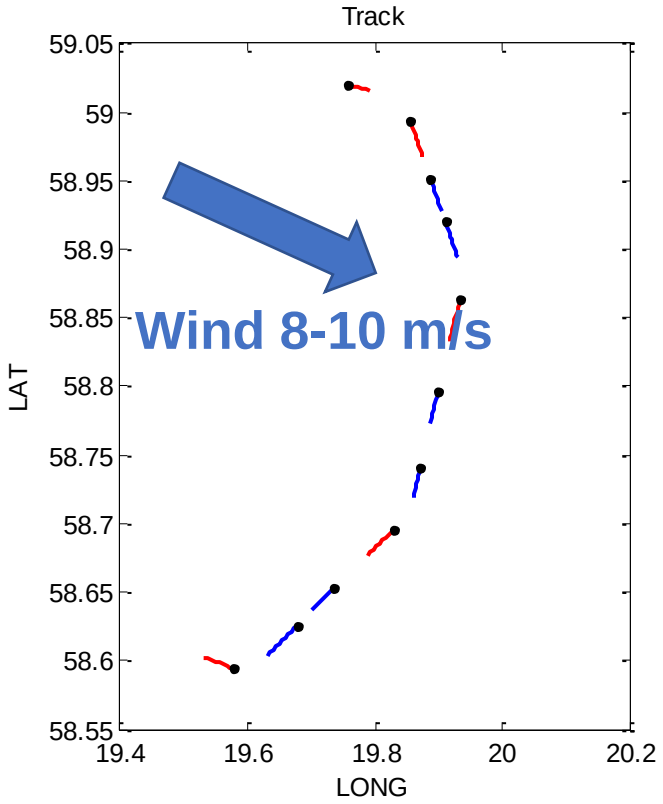
m/v Copenhagen
with Norsepower rotor



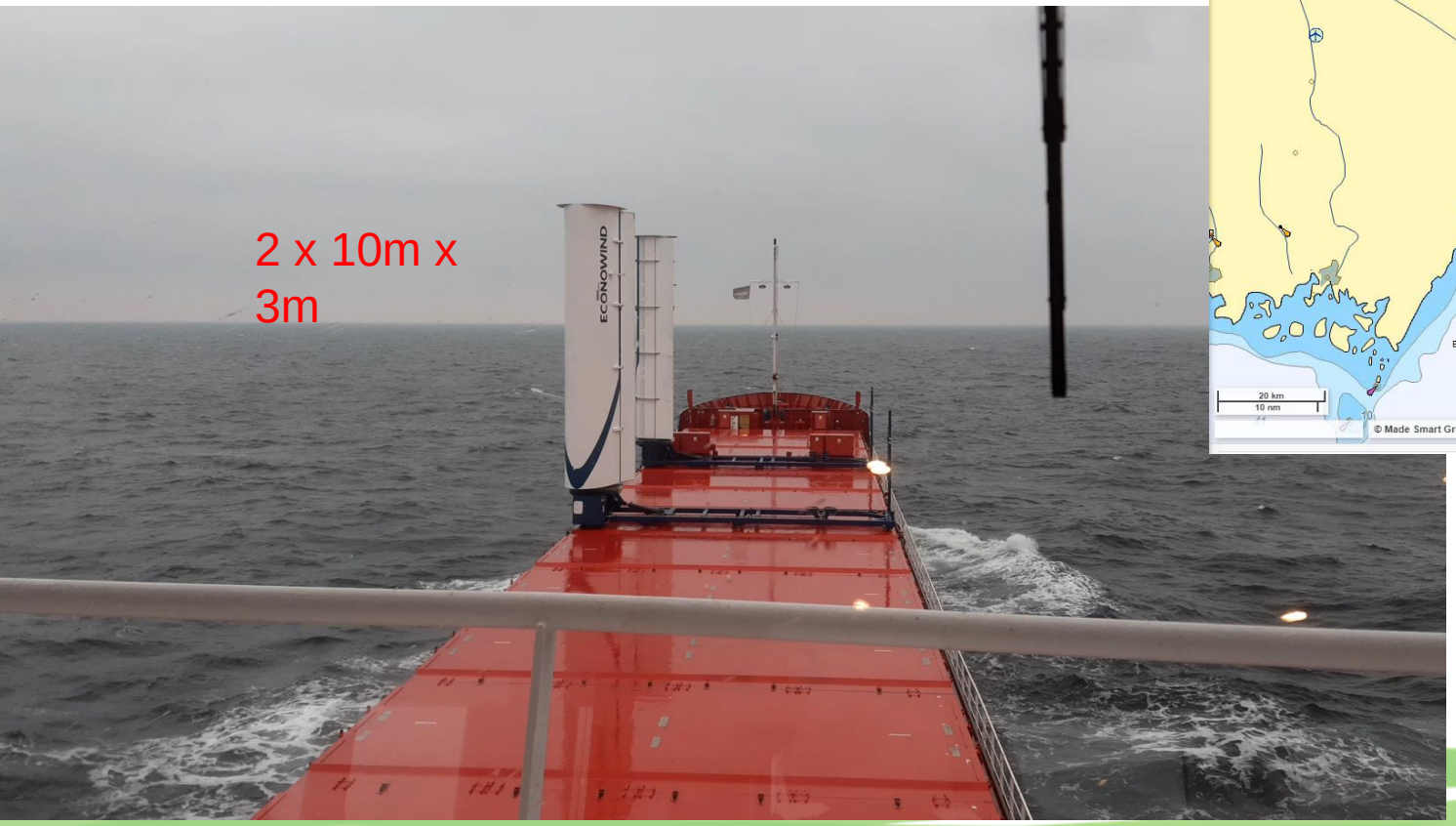
WIND

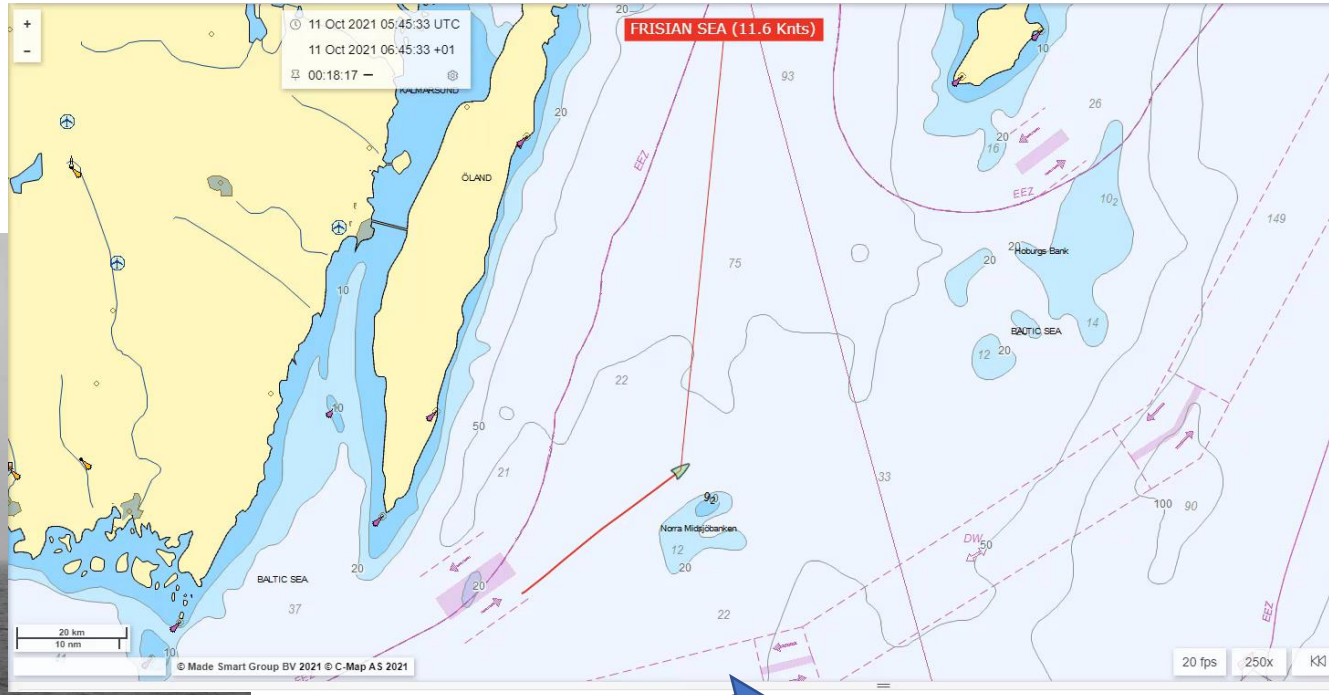
8-10 m/s

Annika Braren
– *with EcoFlettner rotor*



Frisian Sea
– *with Econowind Ventifoils*





Wind 7-9 m/s

Method

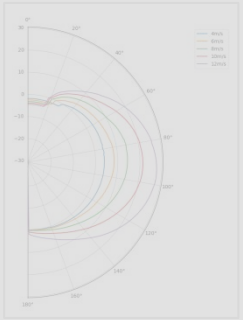
1. Speed trial

2. Analyse speed trial

Power saving 1 wind speed

3. Calibrate virtual ship model

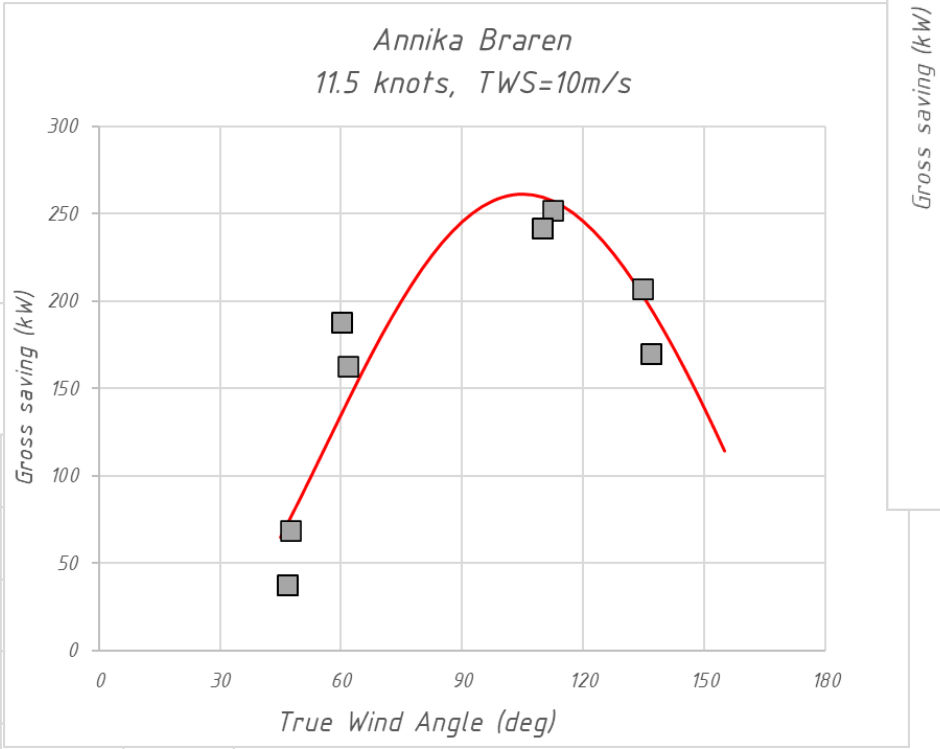
Power saving at any wind condition

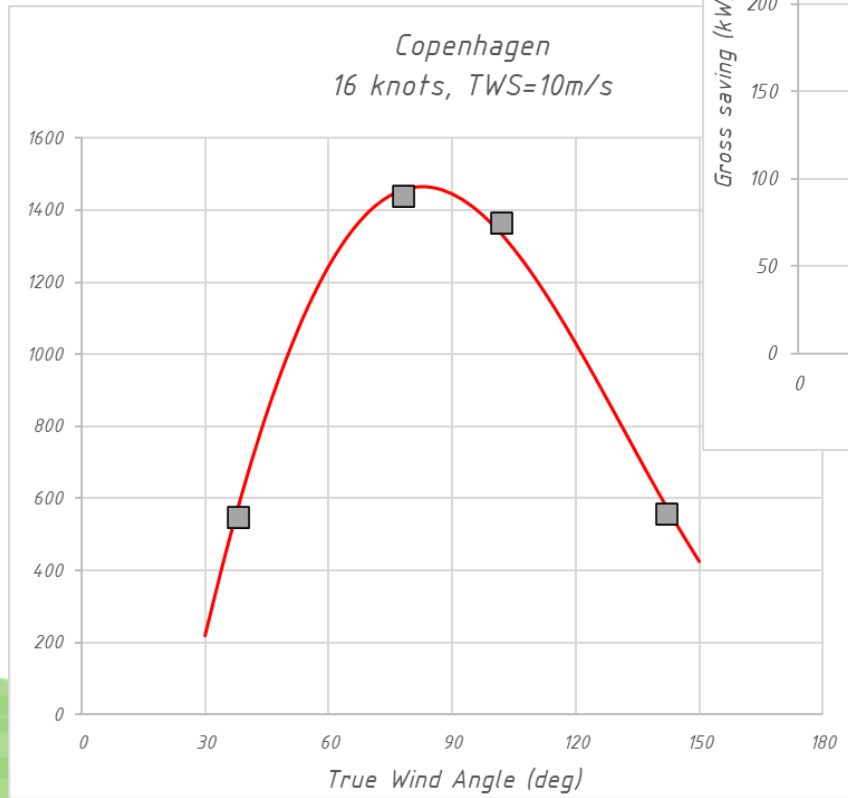


4. Voyage analysis

Average fuel saving

Sea trial results



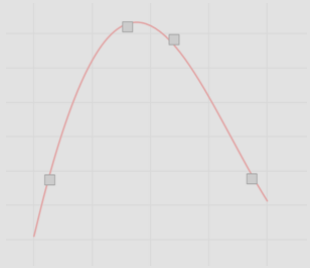


Method

1. Speed trial

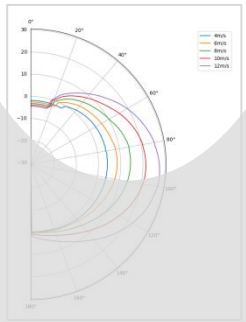
2. Analyse speed trial

Power saving 1 wind speed



3. Calibrate virtual ship model

Power saving at any wind condition

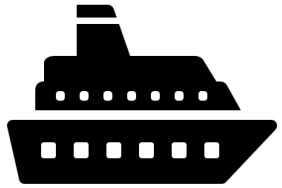


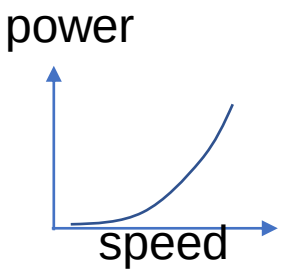
4. Voyage analysis

Average fuel saving

A virtual ship model

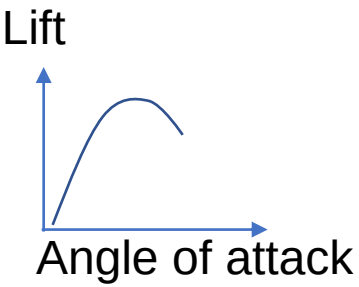
Ship model



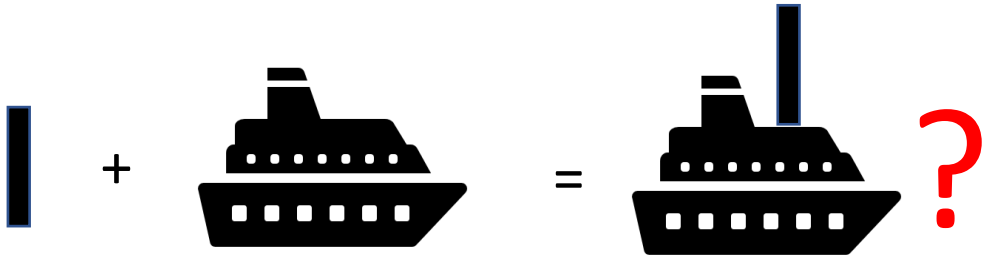


- Propeller
- Rudder
- windage

Rotor / wing model



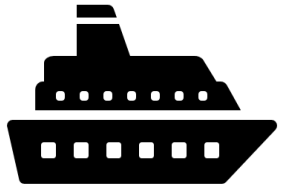
Wind ship model

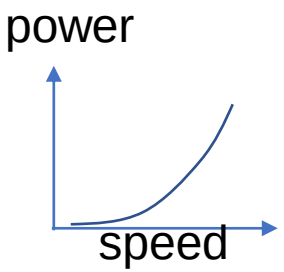


The sum of the two ?

A virtual ship model

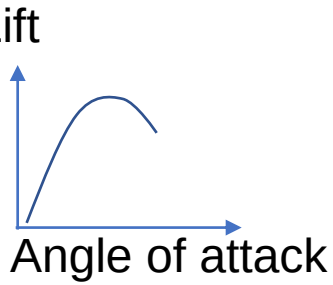
Ship model



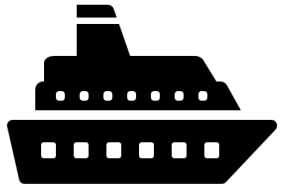


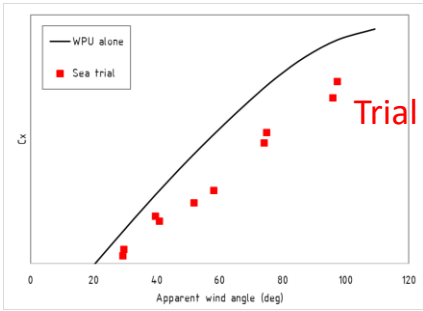
- Propeller
- Rudder
- windage

Rotor / wing model



Sea trial





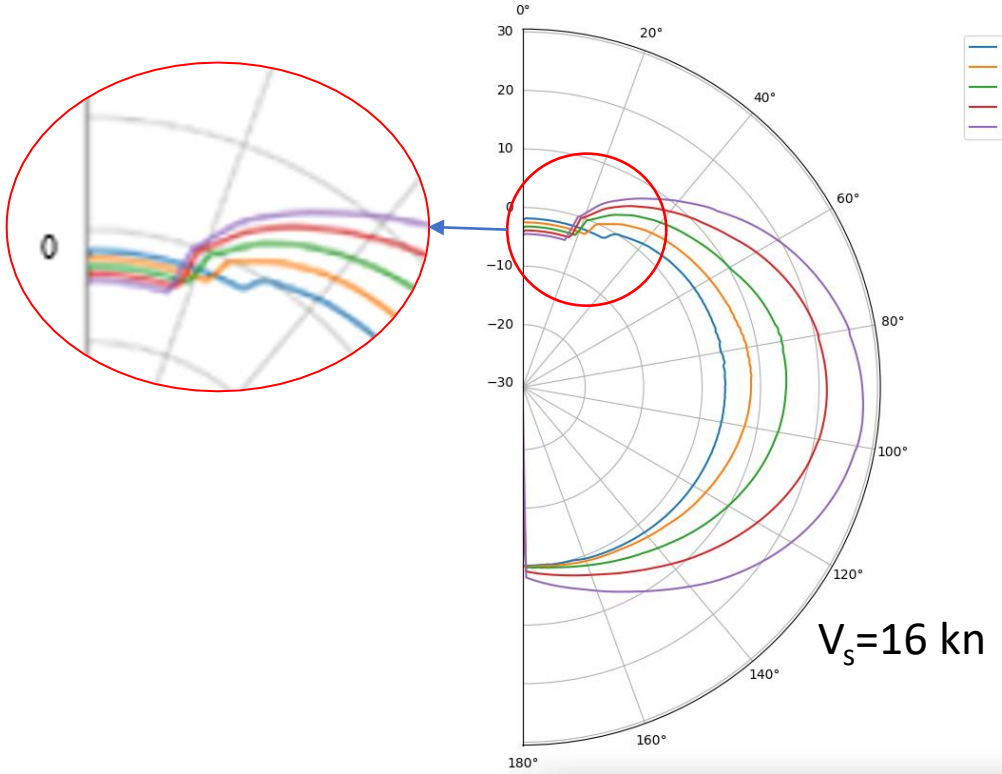
Σ ship + rotor

Trial results

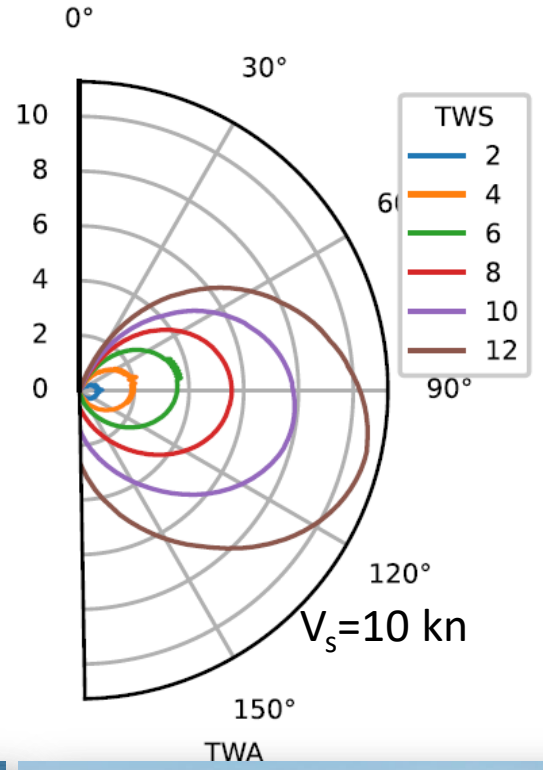
NO!

Significant hull-WPT interaction

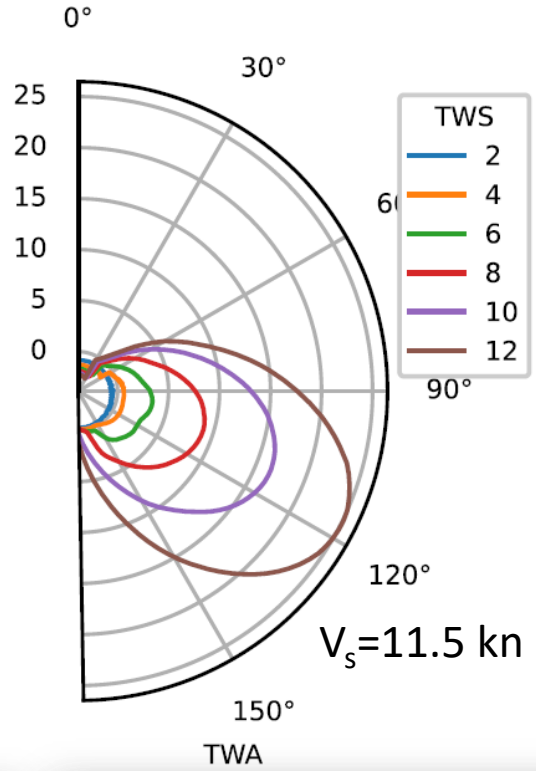
Power saving % (net)



V_s=16 kn



V_s=10 kn



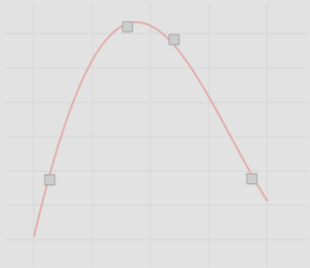
V_s=11.5 kn

Method

1. Speed trial

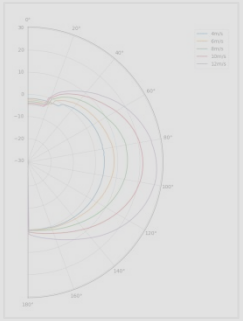
2. Analyse speed trial

Power saving 1 wind speed



3. Calibrate virtual ship model

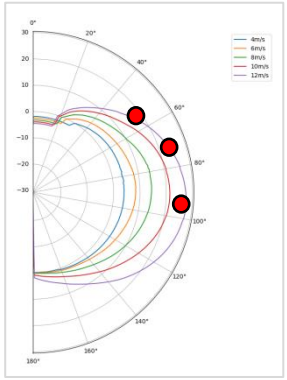
Power saving at any wind condition



4. Voyage analysis

Average fuel saving

Results m/v Copenhagen



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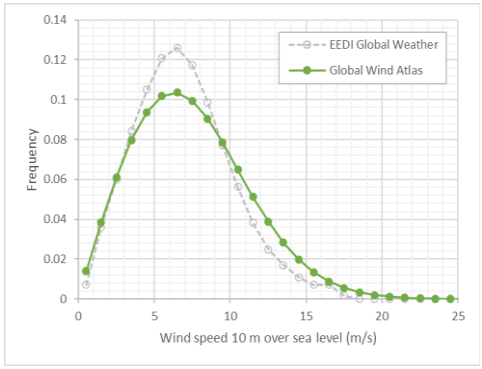


Weather source	Yearly Power Saving
Local weather	3.9%
EEDI Global Weather matrix	2.0%

Results other two ships

Riga - Copenhagen

Bergen - Rotterdam

Head wind

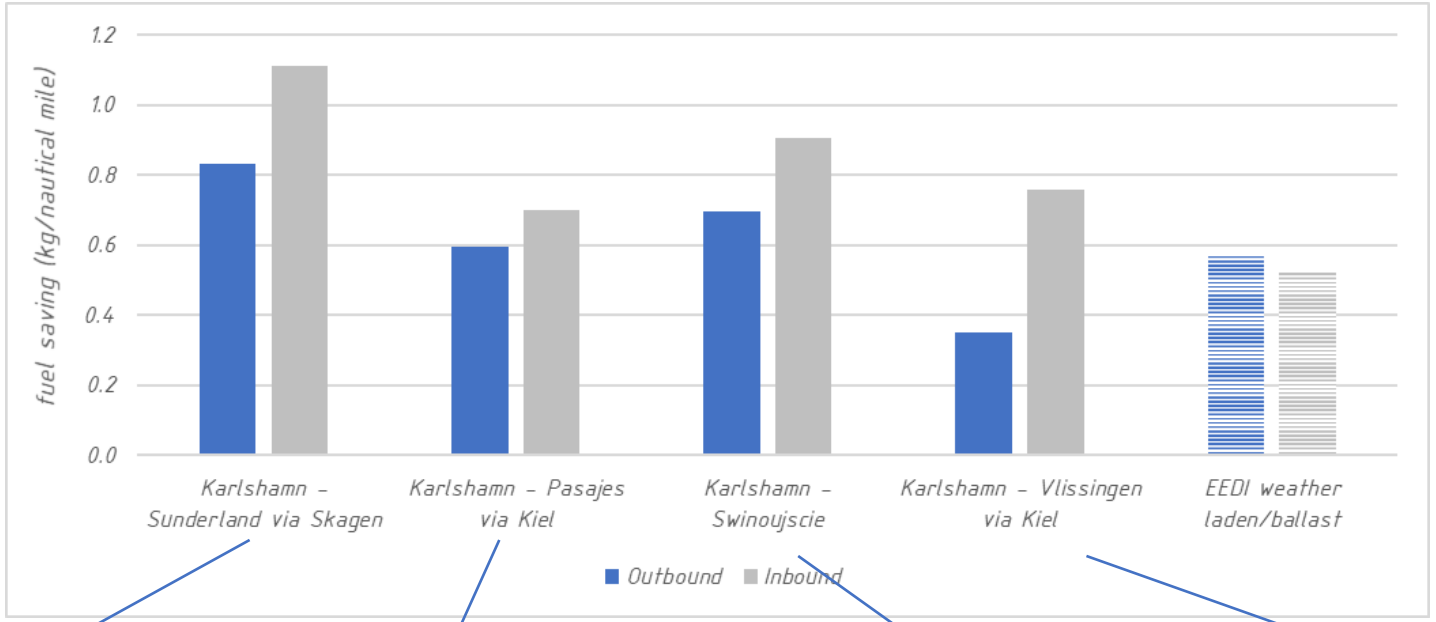
Stern wind

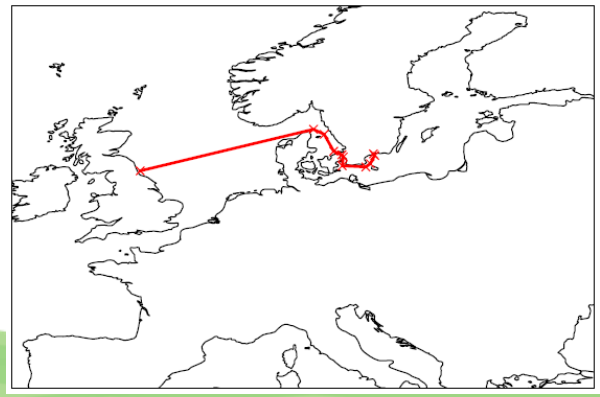
	1.0 m/s	3.0 m/s	5.0 m/s	7.0 m/s	9.0 m/s	11.0 m/s	13.0 m/s	15.0 m/s	17.0 m/s	19.0 m/s
10 deg	0.43	1.45	2.95	4.23	4.31	3.46	2.23	0.70	0.11	0.00
30 deg	0.51	1.57	2.79	3.19	3.25	2.17	0.93	0.29	0.03	0.01
50 deg	0.37	1.45	2.47	2.75	2.49	1.45	0.44	0.10	0.03	0.00
70 deg	0.46	1.34	2.02	2.44	1.99	1.10	0.23	0.09	0.04	0.00
90 deg	0.35	1.36	1.91	2.33	2.29	1.31	0.61	0.06	0.01	0.00
110 deg	0.38	1.49	1.81	2.44	1.97	1.22	0.44	0.12	0.08	0.06
130 deg	0.28	1.09	2.11	2.06	1.47	0.71	0.34	0.00	0.00	0.00
150 deg	0.41	1.08	1.85	2.40	1.31	0.85	0.12	0.00	0.00	0.00
170 deg	0.31	0.89	1.83	2.27	1.61	0.71	0.15	0.01	0.00	0.00

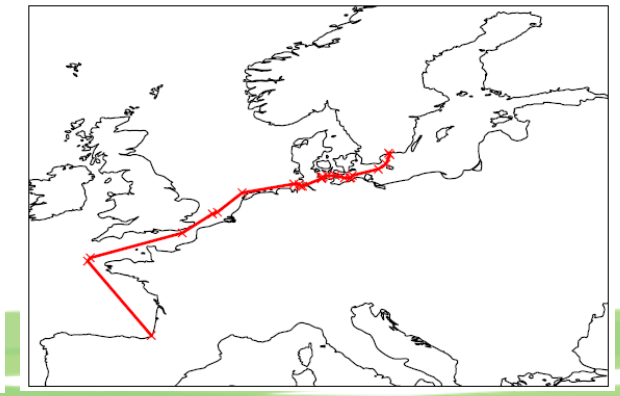
	1.0 m/s	3.0 m/s	5.0 m/s	7.0 m/s	9.0 m/s	11.0 m/s	13.0 m/s	15.0 m/s	17.0 m/s	19.0 m/s
10 deg	0.37	1.52	2.41	2.86	2.64	1.65	0.48	0.26	0.09	0.06
30 deg	0.42	1.34	2.08	2.87	3.08	1.90	0.71	0.31	0.11	0.00
50 deg	0.41	1.19	2.44	3.27	3.50	1.80	0.85	0.35	0.09	0.01
70 deg	0.41	1.19	2.14	2.81	2.65	2.30	0.68	0.29	0.06	0.03
90 deg	0.38	1.18	2.01	2.30	2.37	1.36	0.70	0.31	0.08	0.01
110 deg	0.42	0.97	2.10	2.21	2.26	1.74	0.97	0.48	0.14	0.03
130 deg	0.4									
150 deg	0.3									
170 deg	0.3									

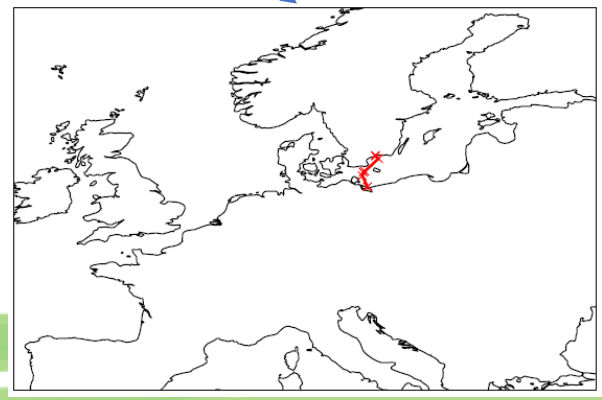
Wind speed

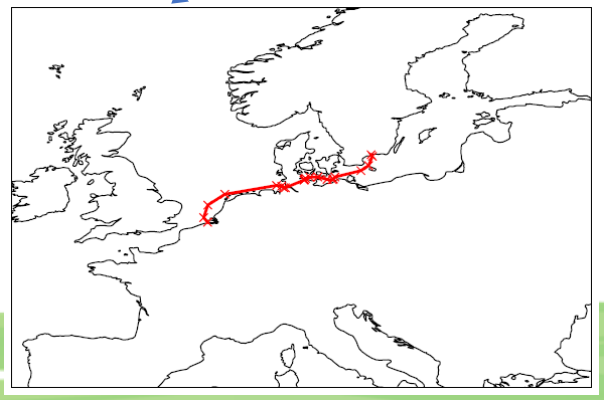
Fuel saving (kg/nautical miles)



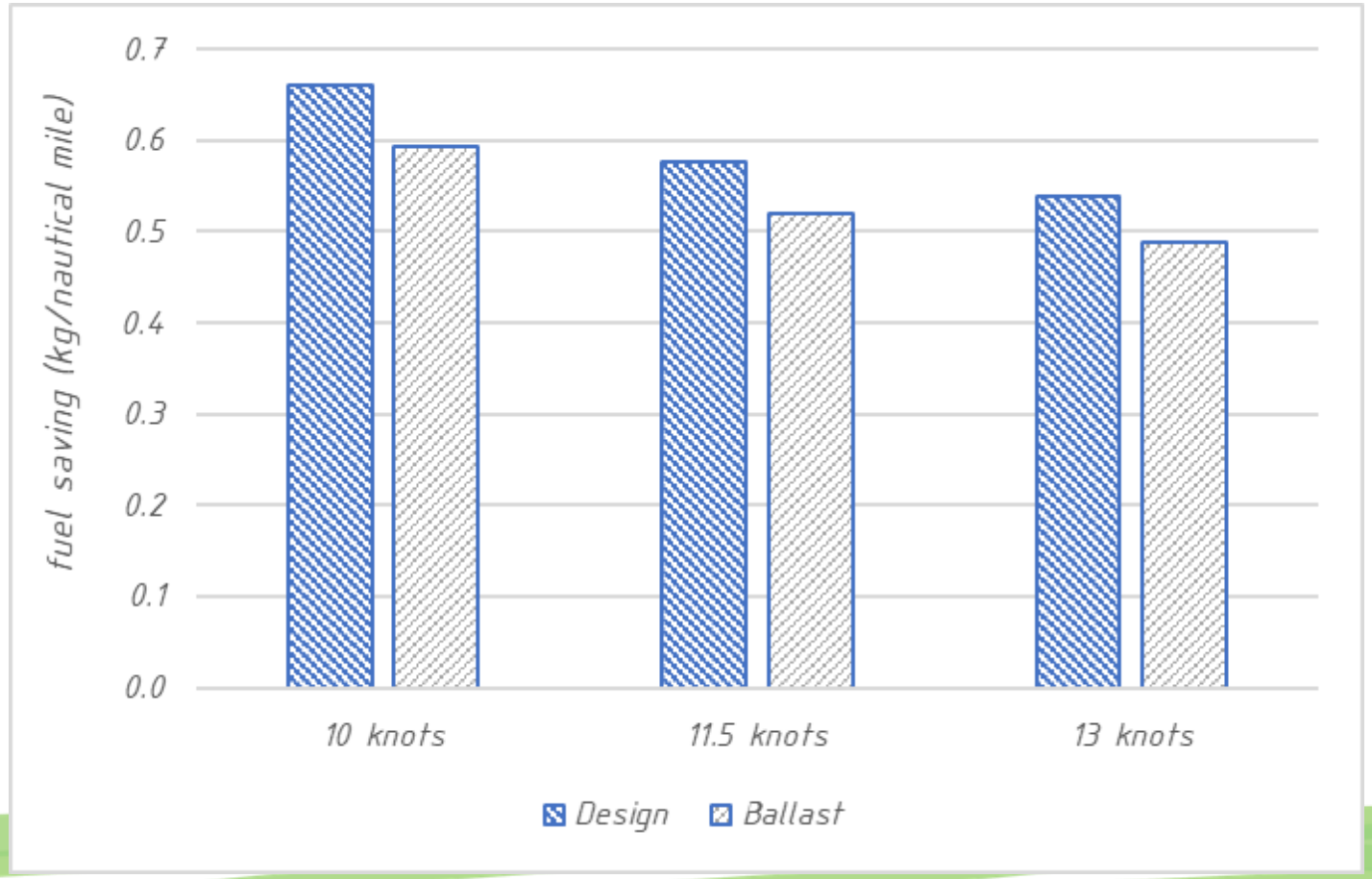








Speed dependency of Fuel saving per nautical miles

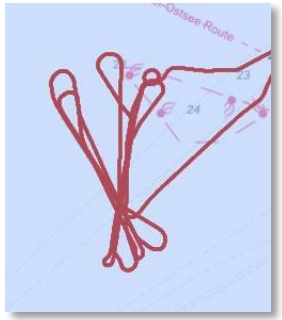


Fuel and CO2 saving

- Estimated average annual saving
- Note: this is the estimated *potential* saving

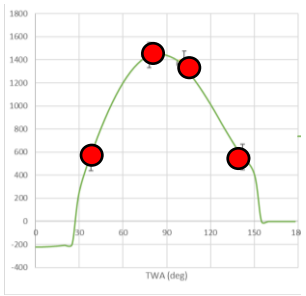
	Fuel saved (ton/year)	CO2 saved (ton/year)
Frisian Sea	27	85
Annika Braren	36	113

1. Speed trial



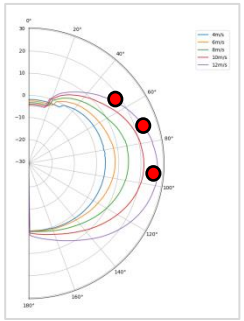
2. Analyse speed trial

rotor thrust at 4 wind conditions



3. Generate virtual ship model

Power saving at any wind condition



How much of the time will the WPT be in used in really?

- Failures
- Maintenance
- Crew hesitancy
- Restricted waters

Changed
Operational profile
Speed
Geographical area

4. Route analysis

Annual fuel saving

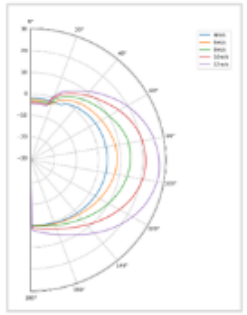
Uncertainties

Usefullness of trial results

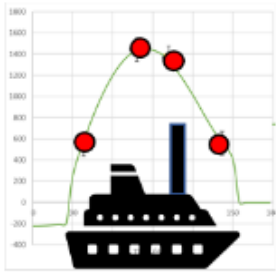
Contract phase

Contract

Power & fuel saving
EEDI EEXI



Sea trial



Verified Ship model

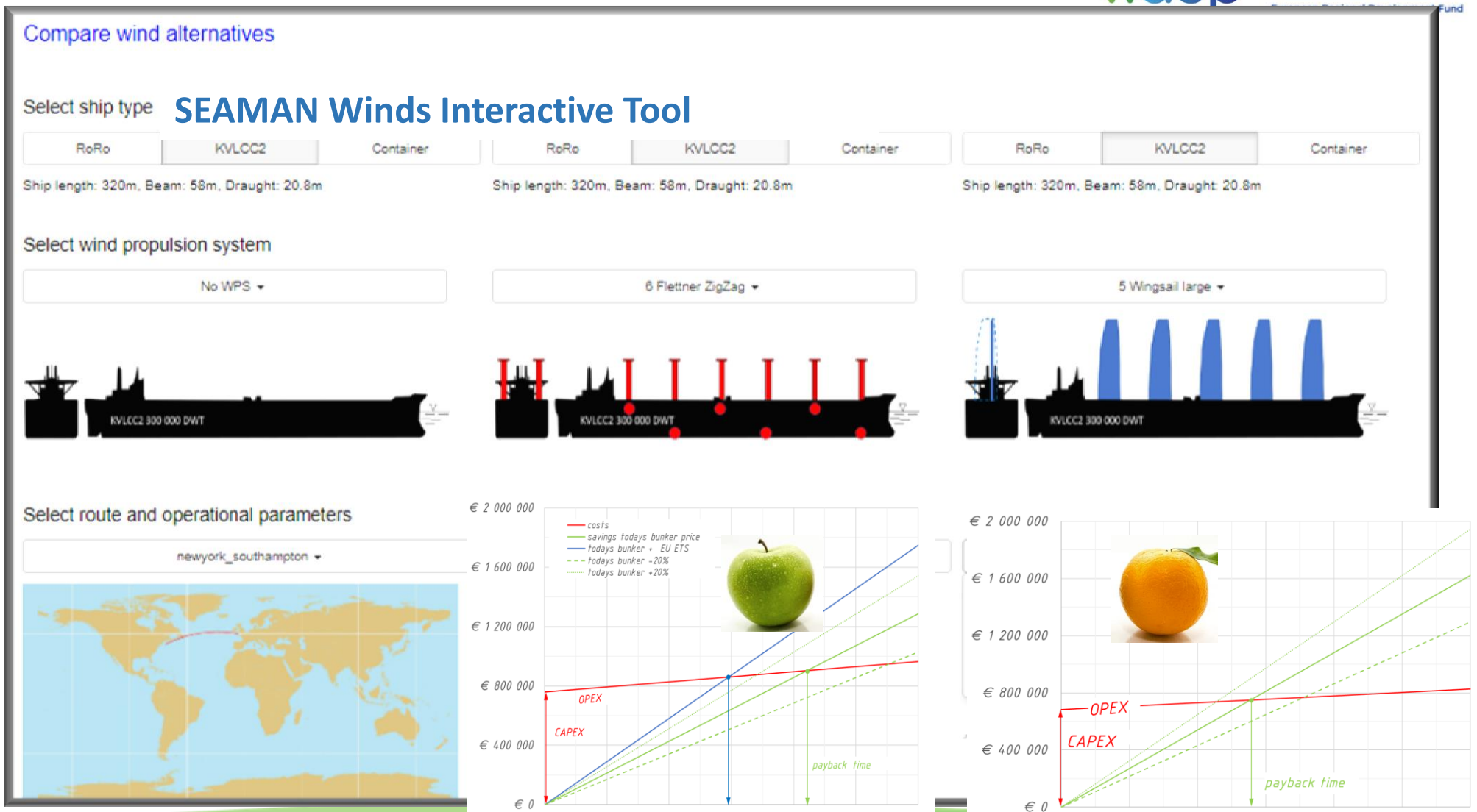
Operation phase

- Route and ETA optimisation
- Fleet optimisation over seasons
- CII strategy and CO2 budget

A word of warning

- This was not a competition between WPTs
- Above numbers cannot be used to rank the technologies relative to each other.
- Ship types, speeds, operational areas, trading pattern etc. are all different

For comparison of WPTs



SSPA.se

Summary

- *Significant power savings have been demonstrated for 3 ships with WPT in sea trials*
- *In total we estimate the potential for saving **800 tons CO2** per year for the 3 ships*

Thank you

The work is financed by Interreg North Sea Region