This is the presentation of Norsepower / OGCI LCFS concept, based on Norsepower Rotor Sails.

Executive summary

- Norsepower Rotor Sails are a proven mechanical sail technology that can reduce the CO_2 emissions of Californian oil import by more than 300 000 metric tonnes per year (13%).
- As with all new renewable energy technologies, also Rotor Sails would need some additional incentives to enable favorable economics for the end users during the start of scale-up.
- There are currently no carbon prices, feed-in tariffs or other programs that would support CO_2 emission reductions of ocean-going vessels.
- LCFS for incoming California crude could be the catalyst to scale up this technology in the tanker business; with LCFS credits, the typical payback period of a Rotor Sail investment could be shortened from 10 years to less than 4 years.

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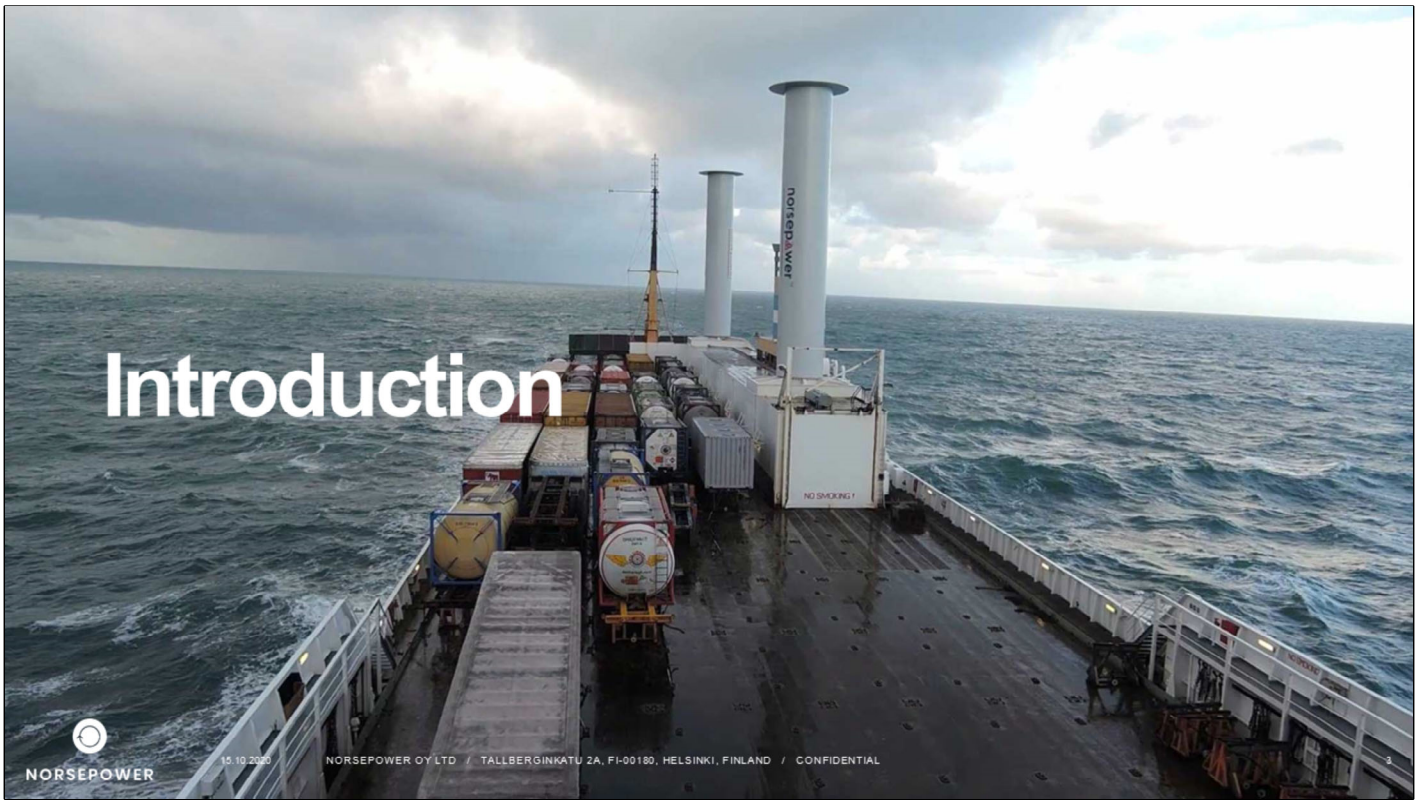

The presentation starts with a short introduction to Rotor Sail technology and the co-presenters.

Visit https://www.youtube.com/watch?v=9JiRueZo8kY to see the video

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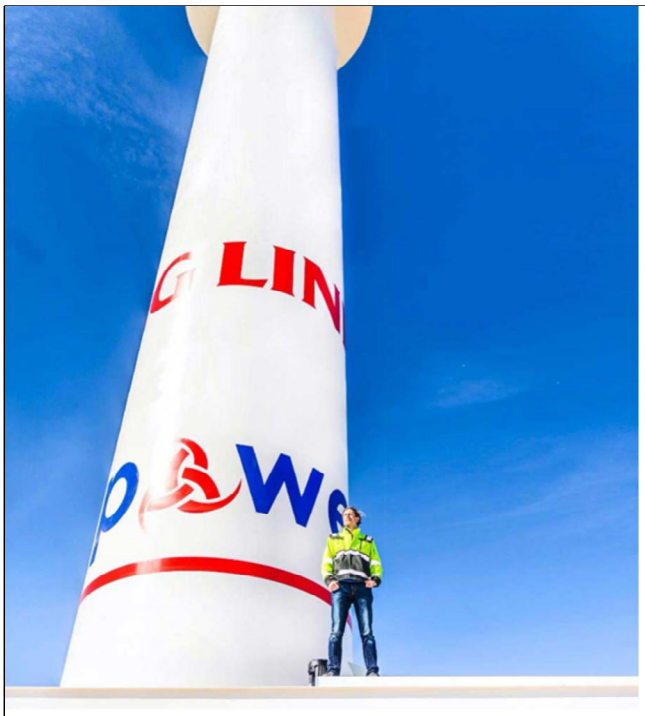
A video showcasing Rotor Sails in action on board several different ships can be accessed through the given link.



Norsepower and OGCI

- Norsepower Oy Ltd
  - Provider of mechanical sails for large ships
  - A privately owned company, main owners are Finnish and UK-based investors
  - Established in November 2012 and based in Helsinki, Finland
  - Growing company with ~5M€ turnover in 2020 and aiming to reach 100 M€ turnover by 2024
- OGCI-Climate Investments
  - Impact investment fund founded in 2017 to support the goals of COP21 climate goals funded my major oil and gas companies
  - Investor in Norsepower Oy Ltd

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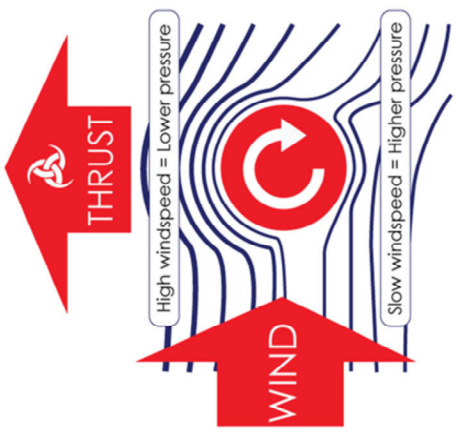
The presentation continues with a concept presentation of Rotor Sails.

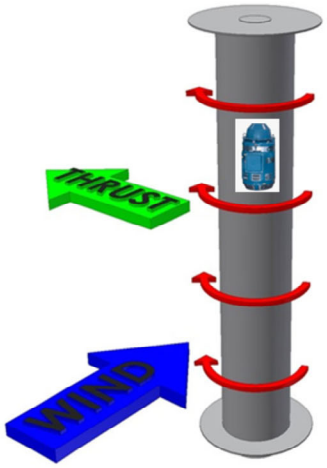
Visit http://tinyurl.com/nmjyzmo to see the Magnus effect demo video

The video which can be accessed through the given link illustrates the Magnus effect which causes flying balls, which have a spin, to fly with a curved path. This phenomena can be observed in f. ex. baseball, tennis and golf.

Physics of the Rotor Sail: Magnus Effect explained

- When wind meets a spinning object, it results in a high and low pressure differential, which creates thrust at a 90 degree angle to the wind
- Flettner (DE) and Savonius (FI) discovered the fundamentals of a “Flettner rotor” in 1920s
- Norsepower has modernised the technology entirely by introducing high tech materials and automated operation





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Rotor Sail is the most efficient mechanical sail in the world – it’s physics are based on a pressure difference caused by the Magnus effect.
Norsepower has modernized the original “Flettner rotor” technology entirely by introducing high tech materials and automated operation.

Reference: LR2 oil products tanker Maersk Pelican

- Two 30 x 5m Rotor Sails were installed as a retrofit in the end of August 2018.
- The LR-verified fuel savings on actual routes of the ship during a 1-year trial period were 8.2%.
- Norsepower forecasts that up to 20% average fuel savings are possible on routes with favorable wind conditions.

"We see wind technology as one of the technologies that can give us a real breakthrough in reducing CO2 and help us achieve our emission-reduction target of 30% by 2021" – Tommy Thomassen, CTO, Maersk Tankers.

Average annual net savings:	**8.2%**
Payback period:	**4-9 years, depending on fuel and routes used**

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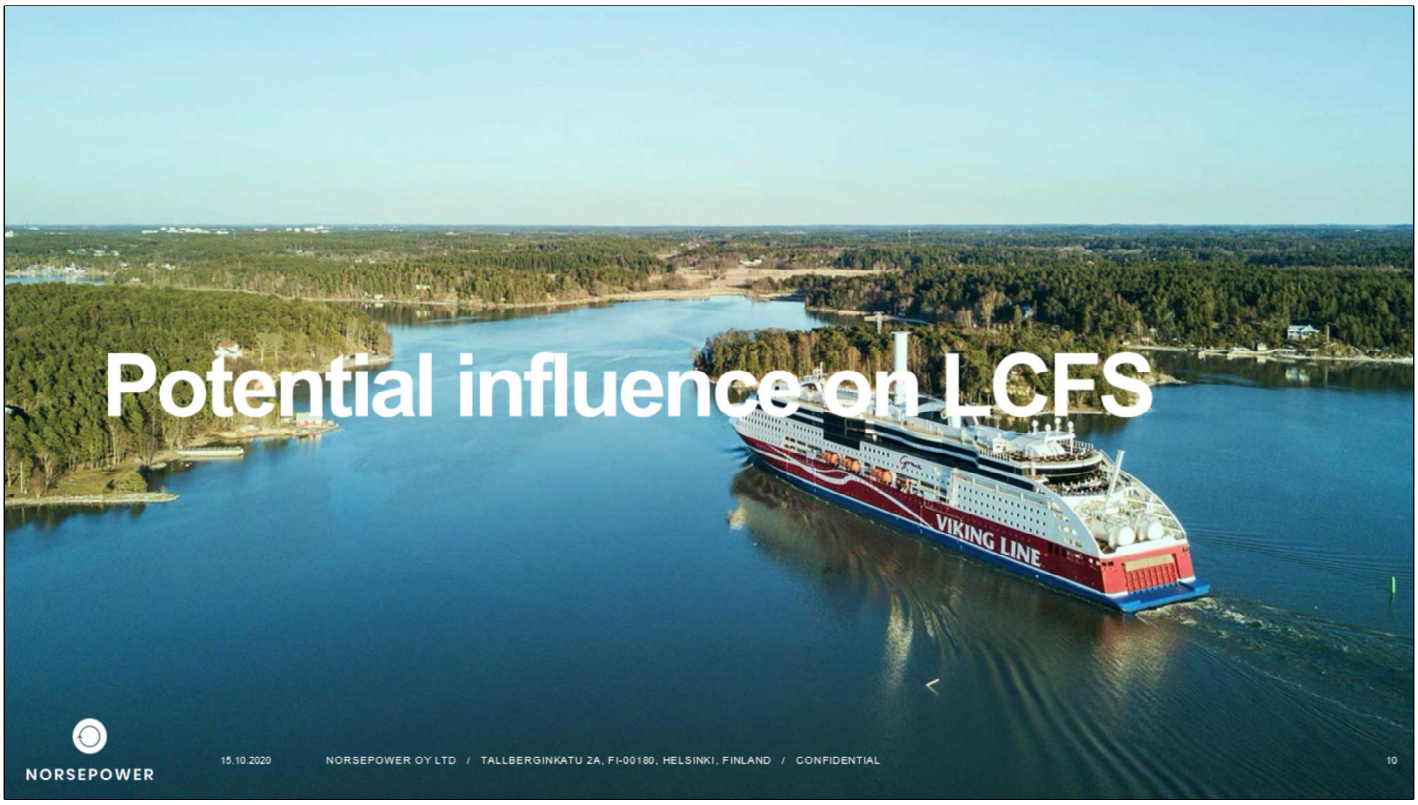
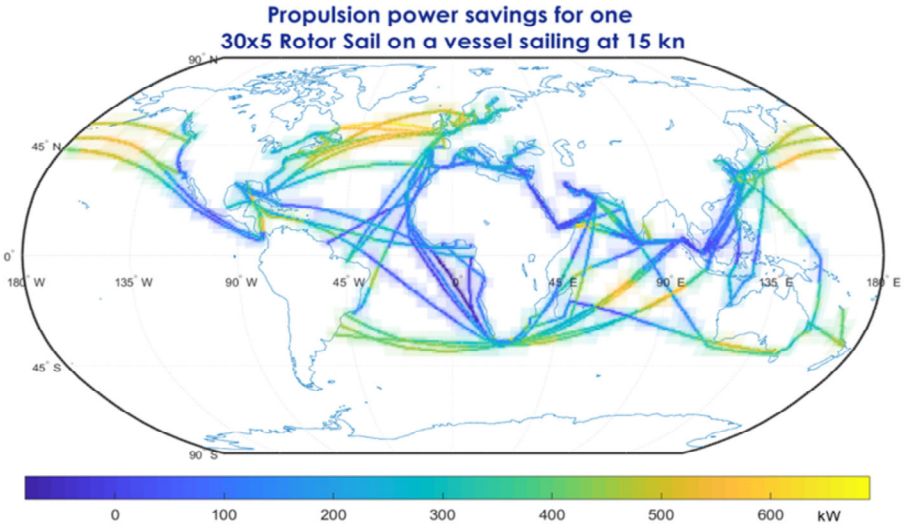
In the Maersk Pelican Rotor Sail project, the Lloyd's Register -verified fuel savings on actual routes of the ship during a 1-year trial period were 8.2%.



The presentation continues with a case study, which illustrates the potential influence of Rotor Sails on LCFS.

Simulated Rotor Sail performance on typical global shipping routes



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As can be seen on the map, the best Rotor Sail performance occurs on Northern Pacific and Northern Atlantic crossings.

Summary of the potential of Rotor Sails on crude import to California

- The CO_2 emissions reduction potential of Rotor Sails on tanker fleet importing crude oil to California was investigated by analysing route simulations on the most active crude oil import routes.
  - Wind data for the simulation is long-term measurements published by DTU and IMO EEDI calculation guidelines.
  - The operational profile and vessel parameters were taken from IMO's 3rd GHG Study.
  - The volume data for import were taken from California Energy Commission's statistics.
- It was concluded that Rotor Sail technology alone could save over **300 000 metric tons of CO_2** emissions every year on Californian oil trade. This corresponds to the annual emissions of over **160 000** passenger cars or 13% of emissions related to propulsion.

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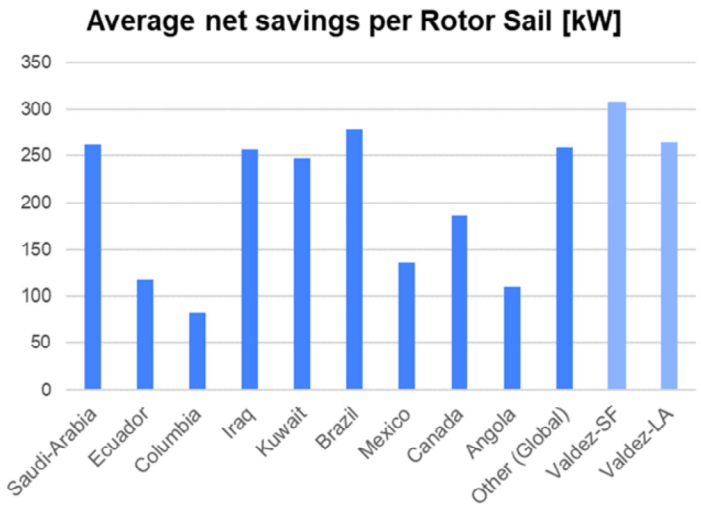
Savings potential on different routes



- Figure presents the average power savings on different routes
- In addition to foreign import routes, trade routes from Alaska to Long Beach and San Francisco were simulated
- The variation on savings potential is mainly caused by higher average wind speeds on ocean crossings
- The highest savings potentials are on routes that have the highest annual “ton-miles”
- In other words, the most important routes have the highest savings potential.

The figure presents the average power savings on different routes.
The variation on savings potential is mainly caused by higher average wind speeds on ocean crossings.
The most important routes have the highest savings potential.

Detailed results

- Table below shows the fuel and emissions savings potential in different vessel size categories.
- Number of possible Rotor Sails per vessel is estimated based on the vessel size
- Number of vessels in each category needed for Californian oil import assumes all categories are similarly represented as in global oil trade
- Annual savings potential with Rotor Sails is **320 000 metric tons of CO_2**
- This corresponds to the emissions of over **160 000** passenger cars
- This corresponds to 13% of emissions related to propulsion
- Including domestic trade from Alaska, the annual CO_2 savings are increased abt. **20 000 metric tons** or **10 000** passenger cars

Ship type	Size category	Units	No. of RS	No. of vessels	Avg. DWT	Avg. sea speed (kn)	Avg. Time-at-sea	Ton-mile per year	Tonmiles transported (%)	No. of vessels needed in CA	Avg. net savings per RS (kW)	Fuel savings (ktons)	CO2 savings (ktons)	CO2 savings (%)
			30x5								30x5			
Oil tanker	10,000-19,999	dwt	2	190	15 129	10	41 %	9.87E+10	1 %	20.79	235	7	22	**21 %**
	20,000-59,999	dwt	3	659	43 763	12	45 %	1.33E+12	5 %	20.79	235	11	35	**14 %**
	60,000-79,999	dwt	4	391	72 901	12	50 %	1.53E+12	9 %	20.79	235	16	52	**13 %**
	80,000-119,999	dwt	4	917	109 259	12	51 %	5.19E+12	13 %	20.79	235	17	53	**13 %**
	120,000-199,999	dwt	5	473	162 348	12	56 %	4.44E+12	22 %	20.79	235	22	69	**13 %**
	200,000-+	dwt	6	601	313 396	13	64 %	1.32E+13	50 %	20.79	235	29	94	**9 %**
												102	**326**	**13 %**

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Table shows the fuel and emissions savings potential in different vessel size categories.

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Continuous measurement method of CO_2 emission reduction

- Each Rotor Sail can be fitted with sensors, which measure the forward thrust produced by each sail on continuous basis.
- International Maritime Organization (IMO) has released guidelines "MEPC.1/Circ.815", which include an equation which enables conversion of forward thrust force of a mechanical sail into main-engine level power saving of the ship.
- When main-engine level power saving, properties of the main engine (SFOC curve),and properties of the fuel used (CO_2 emission factor) are known, it is possible to calculate the actual CO_2 emission reduction on continuous basis.

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Typical investment scenario and potential influence of LCFS

- The approximate cost of typical Rotor Sail investment (2 x 30-meter Rotor Sail) is around USD1.6M, and annual maintenance costs are around USD30k.
- According to the simulation results, the average net fuel savings per 30-meter Rotor Sail when importing crude to California are 220 metric tons per year, equaling 440 metric tons of fuel saved per year for an installation of 2 Rotor Sails.
- With typical historical fuel price of USD450 per metric ton (before Covid-19), **the payback period of the investment becomes 9.5 years**.
- The typical CO_2 emission factor of ship fuels is around 3.1 metric tons of CO_2 per metric ton of fuel used. Hence, USD200 / metric ton of CO_2 (LCFS credit price), equals USD660 per metric ton of fuel saved. **With this value added to the fuel price, the total "fuel saving incentive" becomes USD1110 / metric ton of fuel and the payback period of the investment becomes 3.5 years**.

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Thank you!

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