Western Norway University of Applied Sciences

Implementing Carbon Free Ferry Technology

- Electrical routes in the land of fjords

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Overview

- Research Question
- The Challenge – Contextual landscape
- Electricals Routes for Norwegian Ferries
- From niche to dominant technology – What factors can explain?

Implementing Carbon Free Ferry Technology - Electrical routes in the land of fjords

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Abstract

A game changer for maritime transport is about to be implemented in Norway. Electrical- or hydro-electrical engines will replace 61 ferries in 37 ferry services fueled by diesel the years to come. New ferries are under construction or in the decision making pipeline for ordering. This paper investigates the snowball effect for renewable energy and power supply to other parts of costal Norway on technological-, organizational-/regulative, economic- and political actor aspects of this radical shift of maritime transport technology in the fjords of Norway.

The Norwegian West Coast county council Hordaland took the first initiative. The county council Hordaland decided to organize a process of tender requiring low emission from new ferries with 700 daily departures crossing the fjords (Skauge et. al. 2017).

Our research indicated that this revolution on maritime engines and green energy supply could be explained the combination of new disruptive battery technology, local innovative industry combined with political visons and regulations.

This paper present reflection on following up data for the major decisions for green ferries along the Norwegian Coast. The paper addresses two research questions: What is the disruptive element of the green ferry revolution (Bower and Christensen 1995)? What seems to be the role of marked vs. public policy on risk taking? What driving forces can explain the new wave of electrical fueled vessels? Proactive business actors (Midttun et. al. 2013: 26-) or proactive regulation and risk-taking strategies (Bjerkan et al. 2016) (Braithwhite and Drahos 2000:33-)?

References

1. Bower, J.L and Christensen C.M., 1995. Disruptive Technologies: Catching the Wave. Harvard Business Review (jan-febr): 43-53.
2. Bjerkan, K. Y., et al., 2016. "Incentives for promoting battery electric vehicle (BEV) adoption in Norway. "Transportation Research Part D: Transport and Environment 43:169-180.
3. Braithwaite, J. & Drahos, P. 2000. Global business regulation, Cambridge University Press.
4. Midttun, A. 2013. CSR and Beyond. A Nordic Perpective, Cappelen Damm
5. Skauge, T. H. S. H. O. A. B. T. Ø. J., 2017. Implementing Carbon Free Ferry Technology on West Coast Norway – The Electrical Route. 10th International Scientific Conference. Energy and Climate Change. Proceedings organized by Energy Policy and Development Centre (KEPA) National and Kapodistrian University of Athens, 18.

11th International Scientific Conference on Energy and Climate Change

Session : ie A2 and B1

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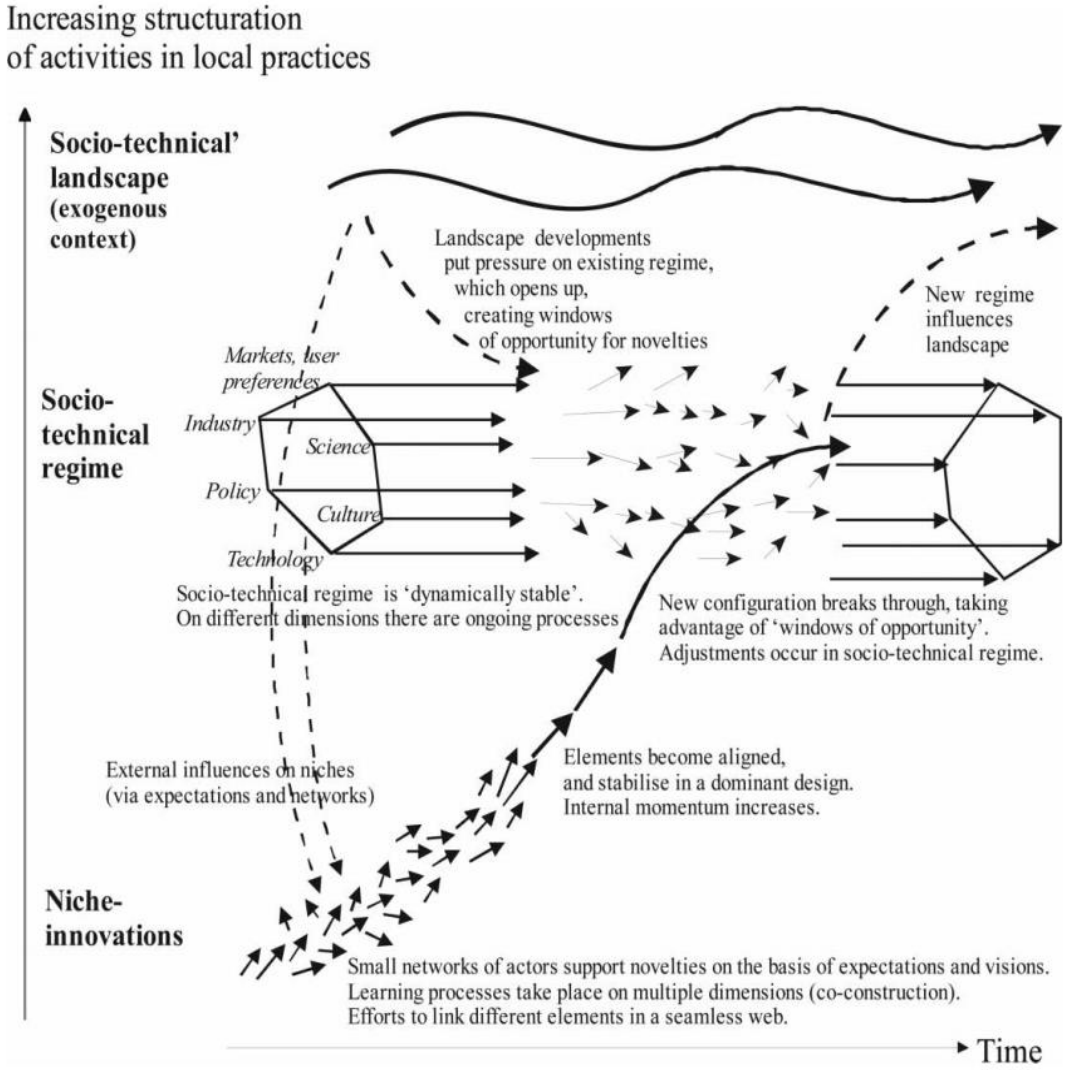
Theory: (Geels)

Landscape

(Context)

Regime

Niche innovations

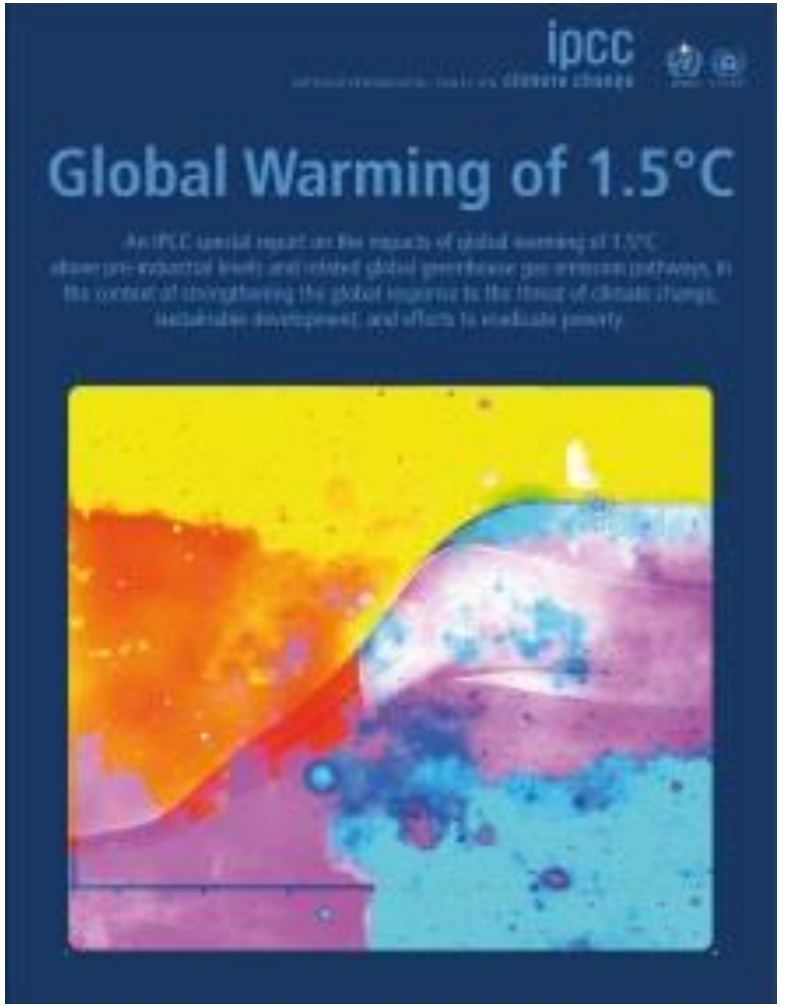


Landscape
The serious context of Global warming

Our challenge: Global surface temperature
IPCC report Monday

The report highlights a number of climate change impacts that could be avoided by limiting global warming to 1.5ºC compared to 2ºC, or more. For instance, by 2100, global sea level rise would be 10 cm lower with global warming of 1.5°C compared with 2°C. The likelihood of an Arctic Ocean free of sea ice in summer would be once per century with global warming of 1.5°C, compared with at least once per decade with 2°C. Coral reefs would decline by 70-90 percent with global warming of 1.5°C, whereas virtually all (> 99 percent) would be lost with 2ºC

"Every extra bit of warming matters, especially since warming of 1.5ºC or higher increases the risk associated with long-lasting or irreversible changes, such as the loss of some ecosystems," said Hans-Otto Pörtner, Co-Chair of IPCC Working Group II. Limiting global warming would also give people and ecosystems more room to adapt and remain below relevant risk thresholds, added Pörtner. "

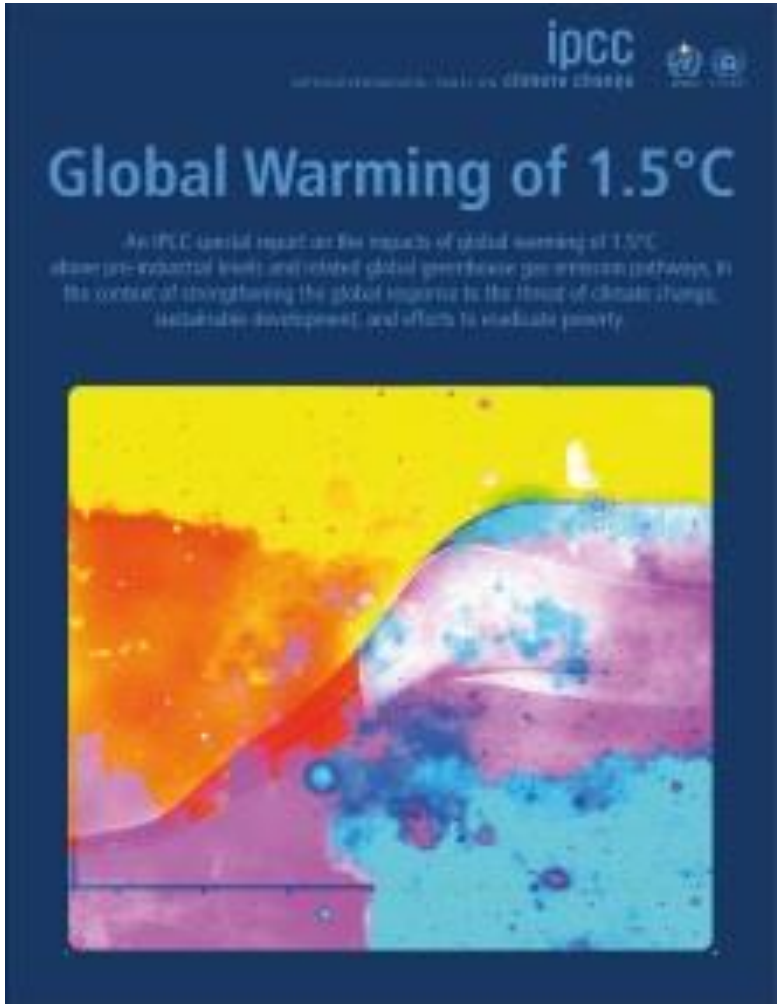


http://www.ipcc.ch/pdf/session48/pr_181008_P48_spm_en.pdf

Our challenge: Global surface temperature
IPCC report Monday

The report noted that emissions need to be cut by 45% by 2030 in order to keep warming within 1.5C.

That means decisions have to be taken in the next two years to decommission coal power plants and replace them with renewables, because major investments usually have a lifecycle of at least a decade.



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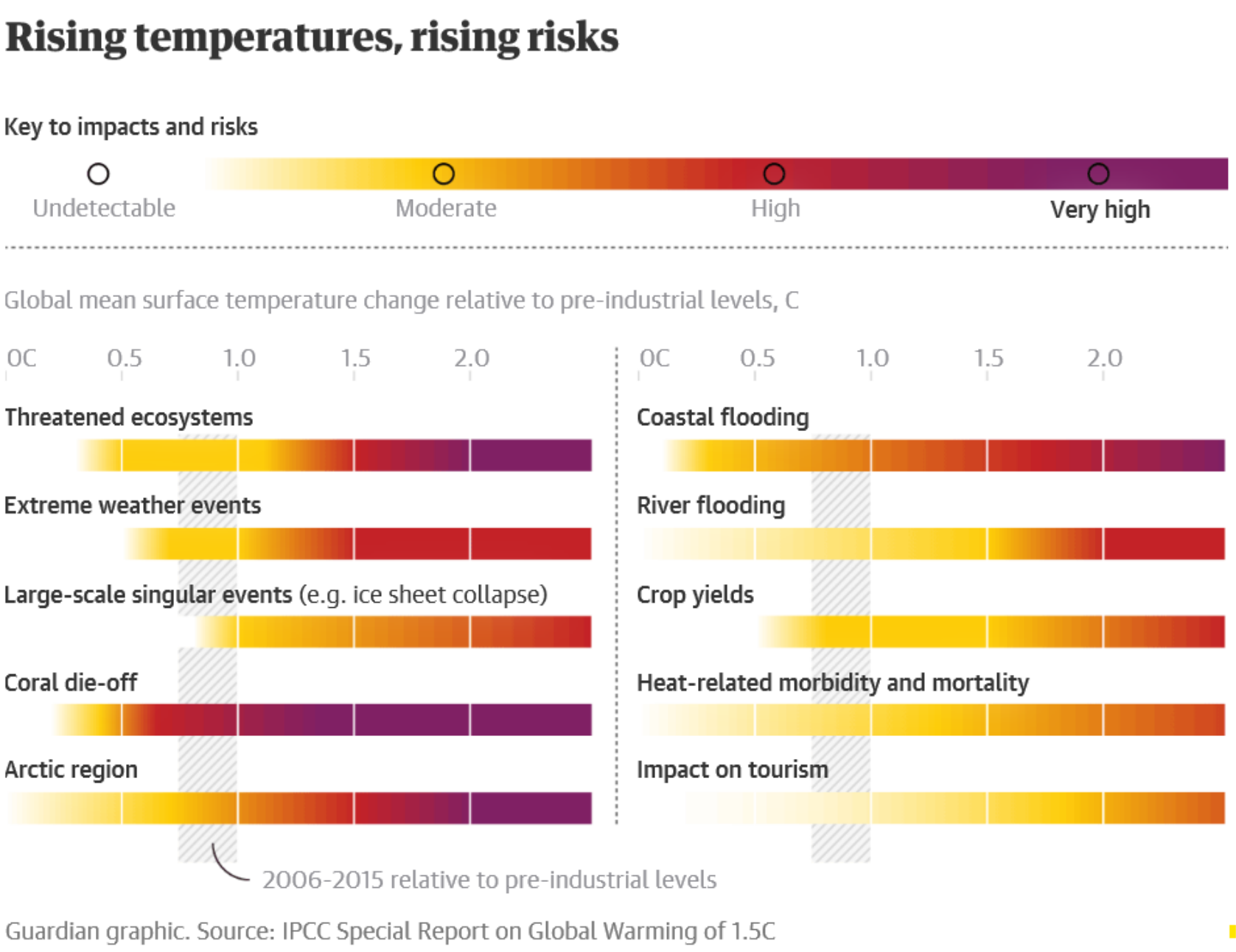
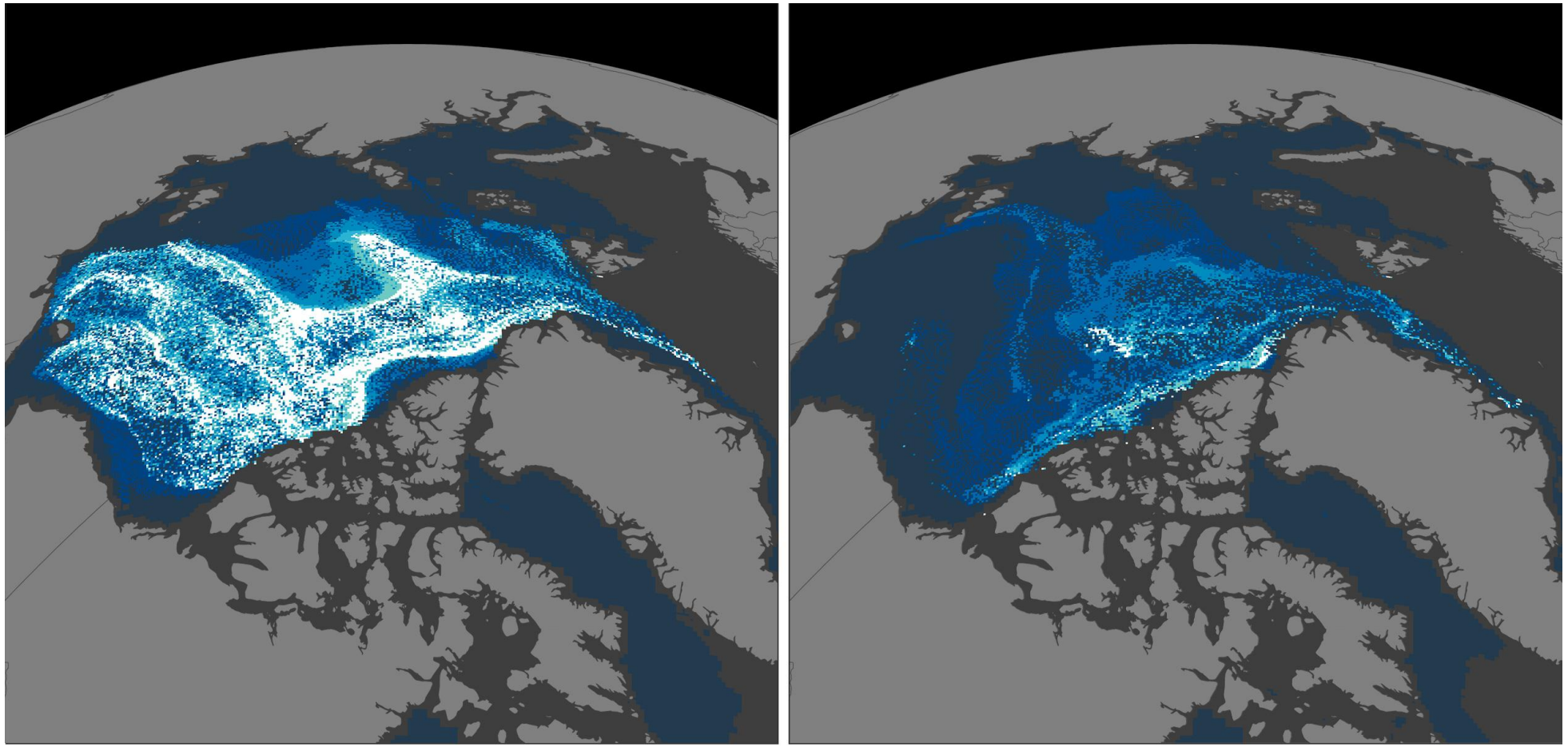
Our Challenge Rising temperatures Rising Risks



Our Challenge:
Old sea ice continues disappearing from the Arctic Ocean



NOAA Climate.gov
Data: Mark Tschudi/NSIDC

Our Challenge: Risk of drought and fires

True scale of CO2 emissions from shipping revealed

The true scale of climate change emissions from shipping is almost three times higher than previously believed, according to a leaked UN study seen by the Guardian.

It calculates that annual emissions from the world's merchant fleet have already reached 1.12bn tonnes of CO_2, or nearly 4.5% of all global emissions of the main greenhouse gas.

The report suggests that shipping emissions - which are not taken into account by European targets for cutting global warming - will become one of the largest single sources of manmade CO_2 after cars, housing, agriculture and industry. By comparison, the aviation industry, which has been under heavy pressure to clean up, is responsible for about 650m tonnes of CO_2 emissions a year, just over half that from shipping.

Until now, the UN's Intergovernmental Panel on Climate Change has estimated shipping emissions to be a maximum 400m tonnes, but the new draft report by a group of international scientists is a more sophisticated measure, using data collected from the oil and shipping industries for the International Maritime Organisation, the UN agency tasked with monitoring pollution from ships. It not only shows emissions are much worse than feared, but warns CO_2 emissions are set to rise by a further 30% by 2020.

The health implications of shipping emissions are most acute for Britain and other countries bordering the English Channel, one of the world's busiest shipping lanes. A recent peer-reviewed study of shipping emissions found world shipping led directly to 60,000 deaths a year.

Electrical routes for Norwegian ferries-
A green revolution

Ferry Connections

- Approx. 200 vessels traffic
- 130 ferry routes in fjords and coastlines of Norway.
- 17 connections are linked to the national road network.
- 113 connections to the county road network
- 21 million vessels annually are transported to
- 365 ferry kays

Electrical- or hybrid-electrical engines will replace aprox 70 ferries in 2022

Ferry Connections
The first mover:
Hordaland
West Coast

"Rutepakke" Packages for tender	Current / former technology	New technology	Expected CO_2 reduction	Expected energy reduction	In traffic from
Package 1: • **Krokeide - Hufthamar** • **Krokeide - Hufthamar** • **Husavik - Sandvikvåg** • **Halhjem - Våge** • **Sløvåg - Leirvåg** • **Fedje - Sævrøy** • **Hatvik - Venjaneset** • **Langevåg - Buavåg**	7 diesel ferries, 1 LNG ferry refitted with plug-in hybrid propulsion	8 ferries where an electrical battery is the main energy source, with a biodiesel-generator as back-up for electrical propulsion	87 %	60 %	3 ferries from 01.01.2018, the rest from 01.01.2020
Package 2: • **Skjersholmane - Ranavik** • **Skjersholmane - Ranavik** • **Jektevik – Nordhuglo -Hodnanes** • **Gjermundshamn - Varaldsøy - Årsnes** • **Jondal - Tørvikbygd**	4 diesel ferries, 1 rebuilt diesel-electric hybrid	4 ferries where an electrical battery is the main energy source, with a biodiesel-generator as back up for electrical propulsion, will be built. 1 ferry has been rebuilt for induction charging	90 %	65 %	01.01.2020
Package 3: • **Klokkarvik - Lerøy - Bjelkarøy - Hjellestad** • **«Fjellbergsambandet»**	2 diesel ferries	High degree for electrification	86 %	58 %	01.01.2020
Package 4: • **Masfjordnes - Duesund**	Cable ferry with diesel generator	Fully-electrical ferry	88 %	65 %	01.01.2020
Package 5: • **Kvanndal - Utne** • **Kinsarvik - Utne** • **Skånevik - Matre – Utåker**	3 diesel ferries	High degree for electrification	92 %	74 %	01.01.2020

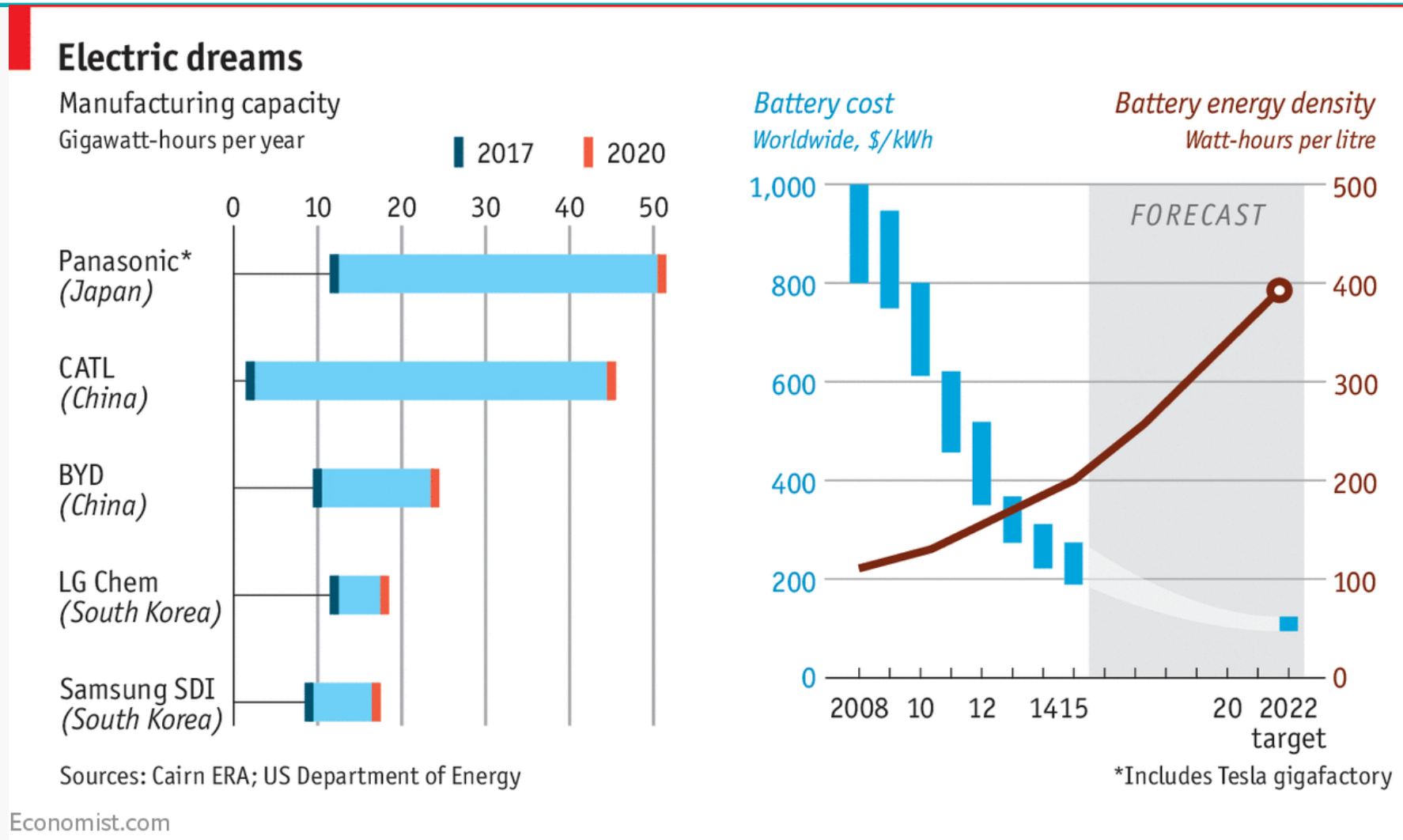
Electrical innovations in the main ferry counties of Norway

County	Current/former technology	New technology	Expexted CO2 reduction	Expected energy reduction	In traffic from
Hordaland	16 diesel ferries, 1 LNG ferry refitted with plug-in hybrid propulsion, 1 rebuilt diesel electric ferry, 1 cable ferry with diesel generator	1 fully-electrical ferry, 12 ferries where an electrical battery is the main energy source, with biodiesel-generator as back-up for electrical propulsion, 1 ferry has been rebuilt for induction charging, 5 ferries with high degree for electrification	86-92%	58-74%	2018: 3 ferries 2020: 16 ferries
Sogn og Fjordane	6 diesel ferries, 2 diesel electric ferries	1 ferry with full electric operation, 5 ferries with at least 80% electric operation, 2 ferries with full electric, 1 ferry will be rebuilt to use biodiesel	2 ferries: 90% 5 ferries: reduction of 9000 ton CO2 each year 1 ferry: 15-20% NOx 1 ferry: no information	2 ferries: 70% 7 ferries: no information	2018: 2 ferries 2019: 2 ferries 2020: 5 ferries
Møre og Romsdal	21 diesel ferries, 7 diesel electric ferries	5 ferries with full electric operation, 5 ferries with full electric operation and diesel engine as backup, 6 ferries with electrical motor and plugin hybrid-technology, 1 hybrid ferry, 2 ferries with high degree of electrification or full electric operation, 5 ferries with low or zero emission of CO2, 1 ferry with minimum 30% and 5 ferries with min. 75% operation with electric power, hydrogen or electrical power used to produce hydrogen on land	11 ferries: 75-89% 4 ferries: min. 15-20% NOx reduction 2 ferries: min. 80% NOx reduction 13 ferries: no information	1 ferry: 15% fuel save 29 ferries: no information	2019: 3 ferries 2020: 17 ferries 2021: 4 ferries 2024: 6 ferries
Trøndelag	6 diesel ferries, 1 diesel-electric ferry, 3 liquefied natural gas engine	2 ferries with full electric operation, 2 ferries with full electric operation and diesel engine as backup, 2 ferries with high degree or full electric operation, 2 hybrid ferries with 43% electric operation, 1 ferry with 50-100% and 1 ferry with 75% plugin hybrid technology, 1 electric cable-ferry	6 ferries: 75% 1 ferry: reduction of 2700 ton CO2 each year. 4 ferries: no information	11 ferries: no information	2019: 6 ferries 2020: 4 ferries 2021: 1 ferry
Troms	4 diesel ferries, 2 diesel electric ferries	6 ferries: high degree of electrification or full electric operation	4 ferries: 67% 2 ferries: no information	6 ferries: no information	2020/2021: 6 ferries
Nordland	14 diesel ferries, 1 diesel-electric ferry with biodiesel	7 ferries with high degree of electrification or full electric operation, 2 ferries with hybrid technology, 3 ferries rebuilt as plugin hybrid, 1 ferry with electrical engine with biodiesel – prepared for plugin hybrid and for full electrical operation, 2 ferries with low or zero emission of CO2	3 ferries: 60% 3 ferries: 90% NOX reduction 9 ferries: no information	3 ferries: 20%. 3 ferries: 20% fuel save 9 ferries: no information	2018: 4 ferries 2019: 1 ferry 2020: 4 ferries 2021: 6 ferries

From niche to dominant technology – What factors can explain?

Technology

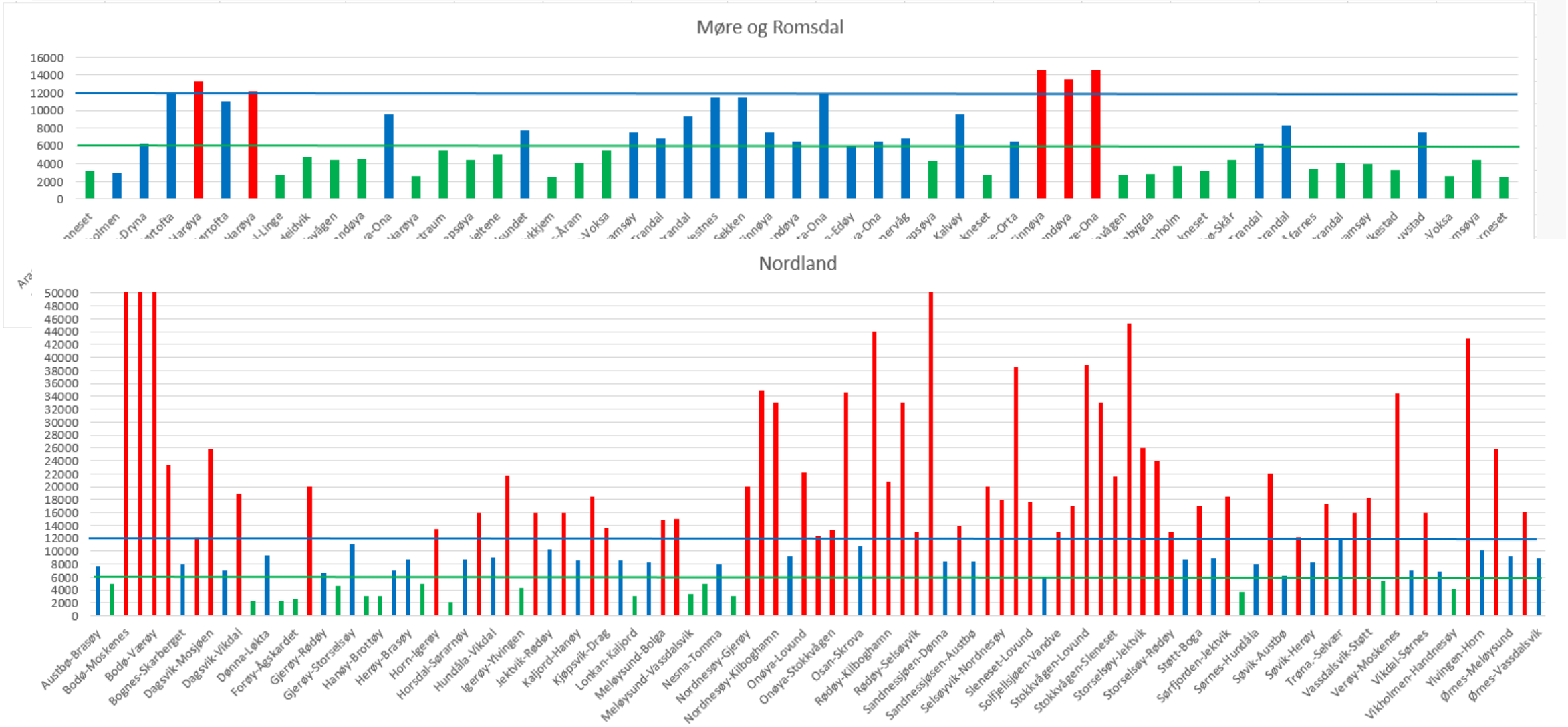
Electrical Dreams
Rapid Innovations for Battery Technology



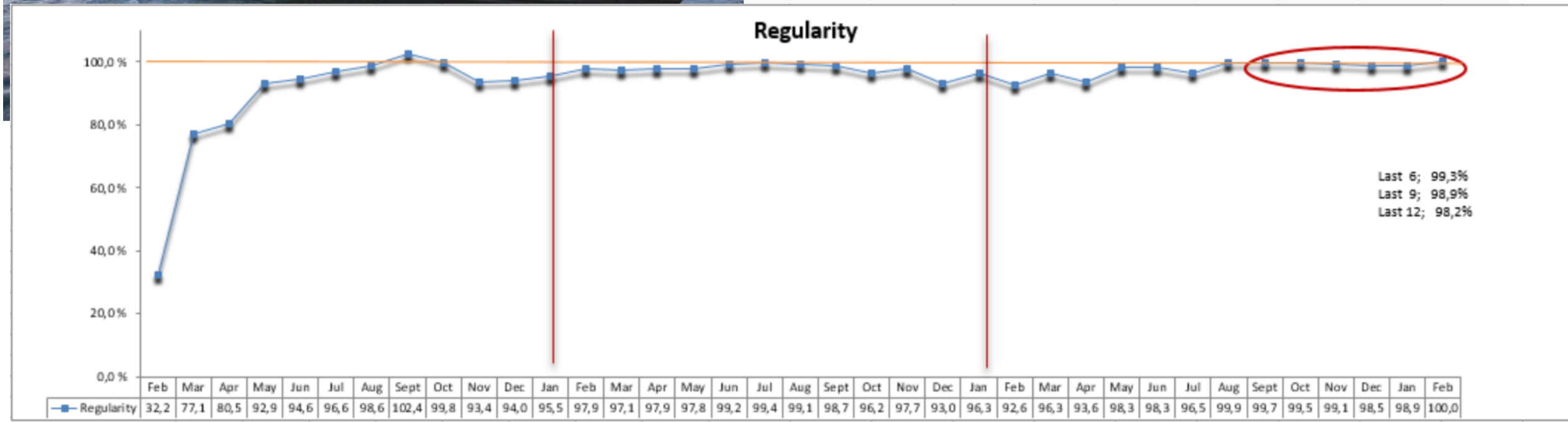
: Battery cost and battery capacity 2008-2022 estimated by Economist.

Effects of new battery technology

Distance from 4-5000 meter few years ago. Today 8-10000 meter



The zero emission technology – electrical engines
Stability in operation of the demonstration project: Ampere



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Regularity	32,2	77,1	80,5	92,9	94,6	96,6	98,6	102,4	99,8	93,4	94,0	95,5	97,9	97,1	97,9	97,8	99,2	99,4	99,1	98,7	96,2	97,7	93,0	96,3	92,6	96,3	93,6	98,3	98,3	96,5	99,9	99,7	99,5	99,1	98,5	98,9	100,0

New technology of charging without contact
Induction

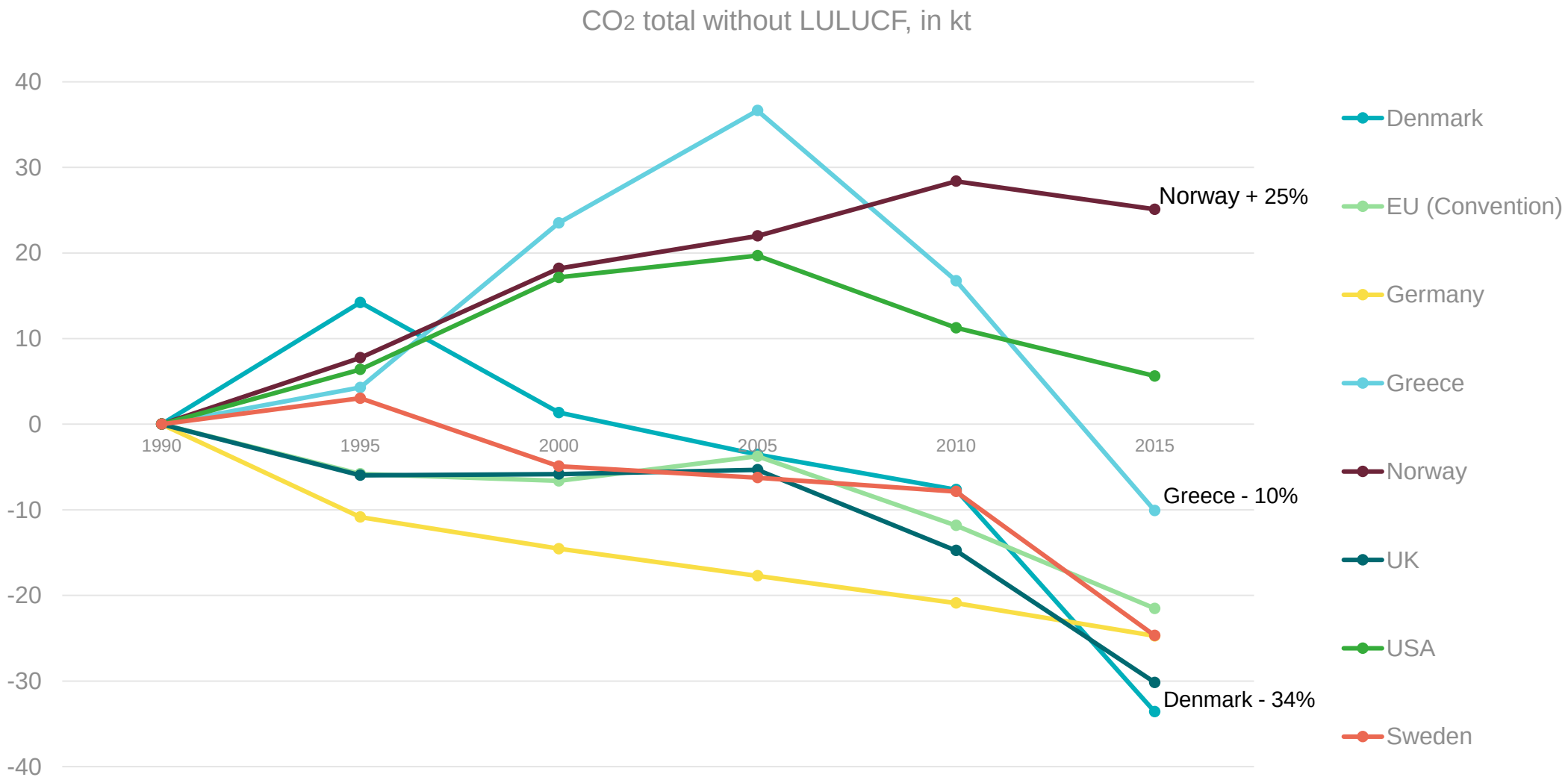
Batteries in the Maritime sector Globally

- Today, more than 200 ships with electrical engines and hybrid ships are in operation or in order - most of them Norwegian.
- According to a recent report from DNV GL, one third of all world ships will have batteries on board by 2050.
- By 2050, greenhouse gas emissions from the world's fleet should be reduced to half of what it was in 2008.
- Batteries are part of the solution.

From niche to dominant technology – What factors can explain?

The construction of tender process

Landscape – Emission Context Norway



Alternatives presented for political decision, Hordaland County Parliament 2015

Alternatives	Minimum reduction CO_2	Minimum increased energy efficiency	Weighting of Environment as an award criteria
Alternative 1	20 %	15 %	20 %
Alternative 2	55 %	25 %	30 %
Alternative 3	35 %	25 %	30 %

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To be competitive

- A public construction of a market:
- 70%: Price
- 30%: Environmental premises: Higher score on CO2 reduction gave success

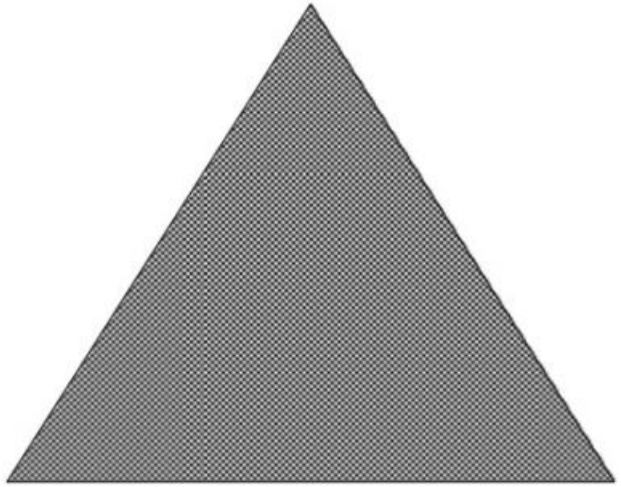
From niche to dominant technology – What factors can explain?

Actors

Theory:
Three dimensions of social acceptance (Wustenhagen et al.)

Socio-political acceptance

- Of technologies and policies
- By the public
- By key stakeholders
- By policy makers



Community acceptance

- Procedural justice
- Distributional justice
- Trust

Market acceptance

- Consumers
- Investors
- Intra-firm

Technological expertise and industrial stakeholders

We find technological expertice:
NCE Maritime CleanTech Strategy

Urban Shuttle
Supported from Horizon 2020

Ferry and express boat operators

Fjord1

NORLED

TORGHATTEN

FosenNamsos Sjø

Political actors

- **Market Pull:** *Norled –Fjellstrand*
  - *CleanTech Cluster*

- **Market Creators** – Market Push:

Political institutions and NGO's

- **Norwegian Parliament:**
  - Asked for zero emission tender for ferry connections
    - **County Parliament Hordaland – First mover:**
    - Implemented low/zero emission for new tenders

- **NGO's**

Political Mobilization

Parliament Dec. 2014

«Stortinget claim from Government:

All new tender should claim zero or low-emission in new ferry technology

-

Regional Transport Committee

Unanimous decision

Krev statleg hjelp til ferjerevolusjon

Fylkespolitikarane i Hordaland vil ha vekk dei forureinande dieselferjene. No krev dei at staten tar ein stor del av rekninga.

MF Ebne: På strekninga Leirvåg-Sløvåg går den over 30 år gamle MF Ebne i trafikk. Snittalderen til ferjeflåten i Hordaland er 27 år.
FOTO: HARALD SÆTRE

Journalist
Sølve Rydland

MER OM NORGE
MER OM SAMFERDSEL

Oppdatert 21.01.2015, kl.

Eit samrøystes samferdsleutval gjekk onsdag inn for å stilla langt strengare miljøkrav til dei som skal driva dei 16 ferjesambanda i fylket.

Flest mogeleg av dei gamle dieselferjene skal vekk, og erstattast med låg- eller nullutsleppsferjer, når alle ferjekontraktane skal fornyast fram mot 2020.

– Dette kan alle vera fornøgde med, seier Frp-ordførar i ferjeavhengige Austevoll, Renate Mægster Klepsvik, som har ropt høgt om eit nyare ferjer.

Ferjefylket Hordaland

- Hordaland har 16 ferjesamband i fylkeskommunal regi, i tillegg til ett ferjesamband i statleg regi.
- Er det nest største ferjefylket i landet målt i personbileiningar.
- Gjennomsnittsalderen på dei fylkeskommunale ferjene er 27 år.

Summing up
factors for successful route from niche to dominant regime

TECHNOLOGY

1. New efficient, cheaper battery technology
2. Demonstration project success
3. Grid systems to the kays

INDUSTRIAL-INSTITUTIONAL CAPACITY

4. Entrepreneurial industry og shipyards
5. Innovative oriented Ferry operators

POLITICS

6. Political will to implement Paris goal
7. Tender construction.
8. Risktaking

Actors summing up

Explaining the success

Moving from niche to an new

Standardised regime

-electrical routes

Western Norway University of Applied Sciences

Thank You for your attention

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