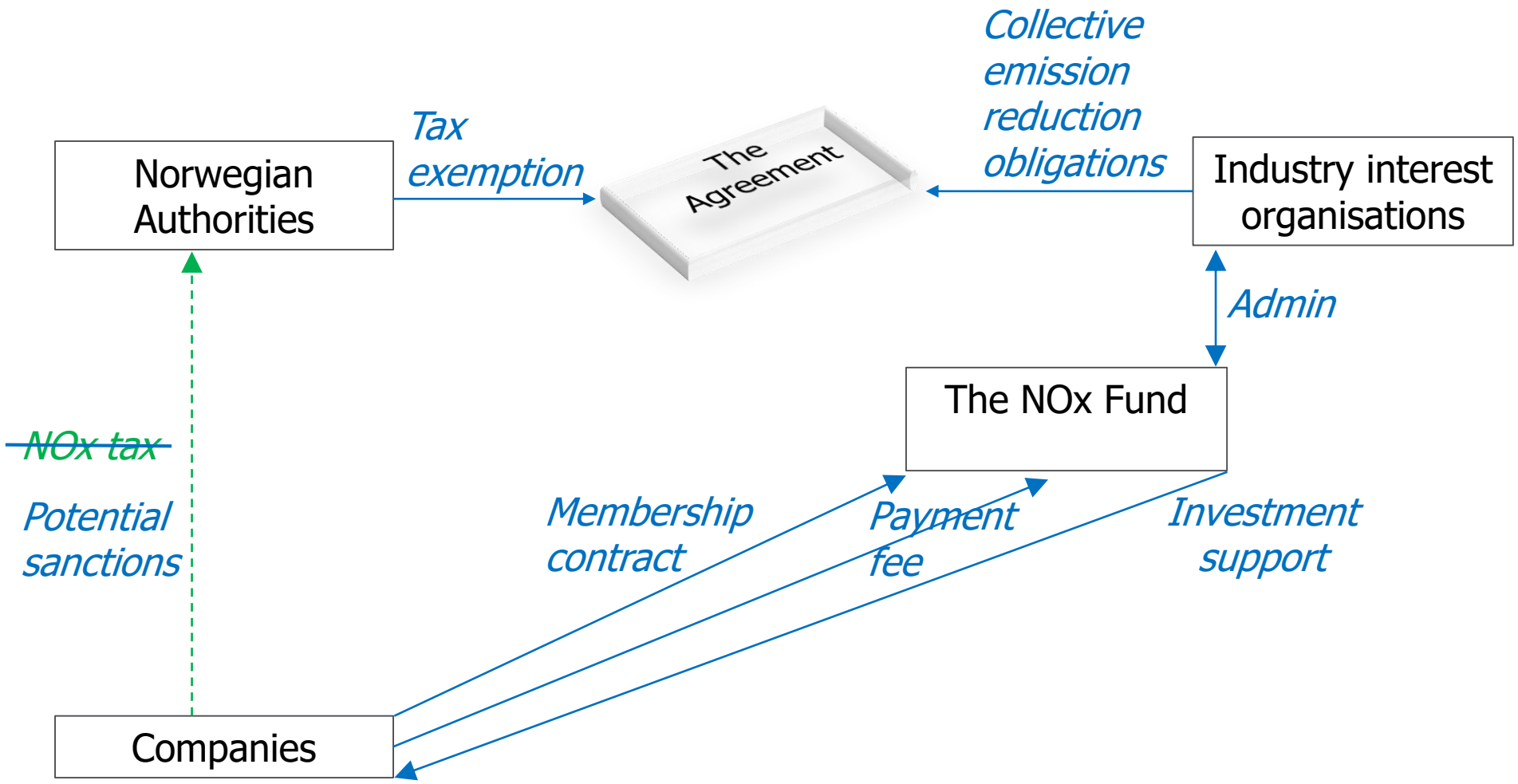
9 April 2019– Tommy Johnsen

Potential for liquified biogas as fuel in shipping

NOx-fondet

Together to cut NOx emissions

NOx tax, Agreement and Fund



NOx-fondet

The NOx Fund has provided extensive investment support to LNG fueled ships (3,2 billion NOK in total)

LNG resulting reduction in NOx and GHG

- Competitive OPEX (incl. fuel price) compared to MGO is an important driver for LNG, especially taking into account environmental taxes and costs resulting from new emission requirements.
- Conversion of ship engines from diesel (MGO) to LNG reduces emissions from the ship significantly:

  ✓NOx-emissions by 80-95%

  ✓GHG-emission by 0-25%, including methane slip
  (depending on engine age and type – the newer the better)

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LNG is a good short term GHG reduction measure in shipping, although further improvement is needed

- In April 2018, IMO adopted a Strategy on reduction of GHG emissions from ships:
  - *To reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008*
- The NOx-fund is challenged (by environmental NGOs) if the effort to reduce NOx and GHG in Norway short term by LNG is in conflict long term GHG targets
- The NOx Fund believes there is no conflict because:
  - There is no other short term technical solution. Ship owners stopping to build new ships awaiting technology leaps is not an option.
  - Investing is LNG with aim to tap in LBG is in line with the IMO strategy, especially for coastal shipping (in Norway)

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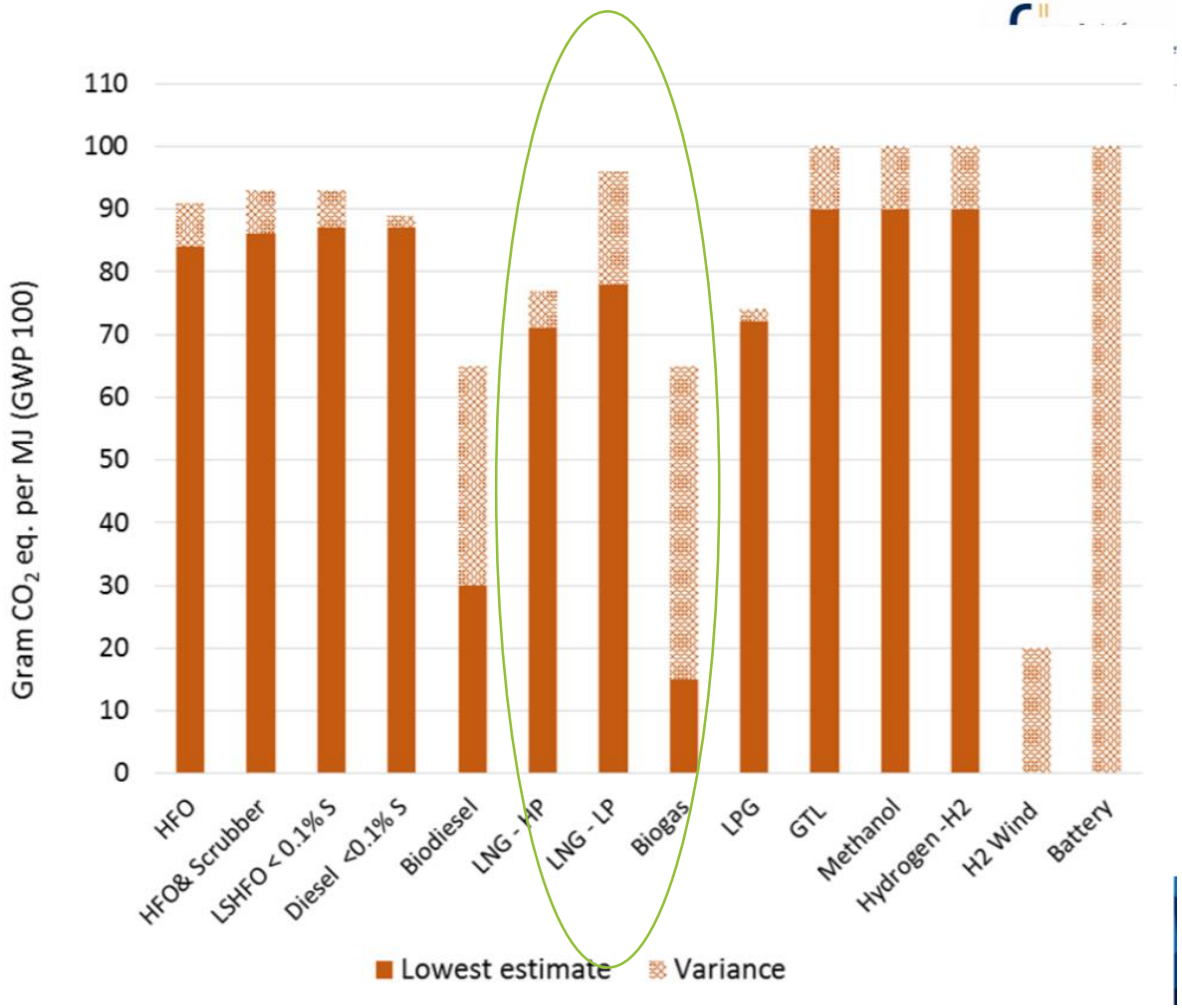
CO2-eq. emissions from LNG, biogas and other fuels in a life cycle perspective

Well to Wake (WTW) emissions for alternative versus traditional fuels in shipping

– a Review of published studies



Ref. Sintef Ocean

SMART MARITIME

NOx-fondet

Biogas tap-in benefits for maritime

- Biogass can be better than climate neutral, when the resource utilisation prevents uncontrolled biological degradation
- Biogas is 179% renewable (IEA)
- Biogas is waste management reducing GHG
- Biogas and LBG is already industrialised (in other industries)

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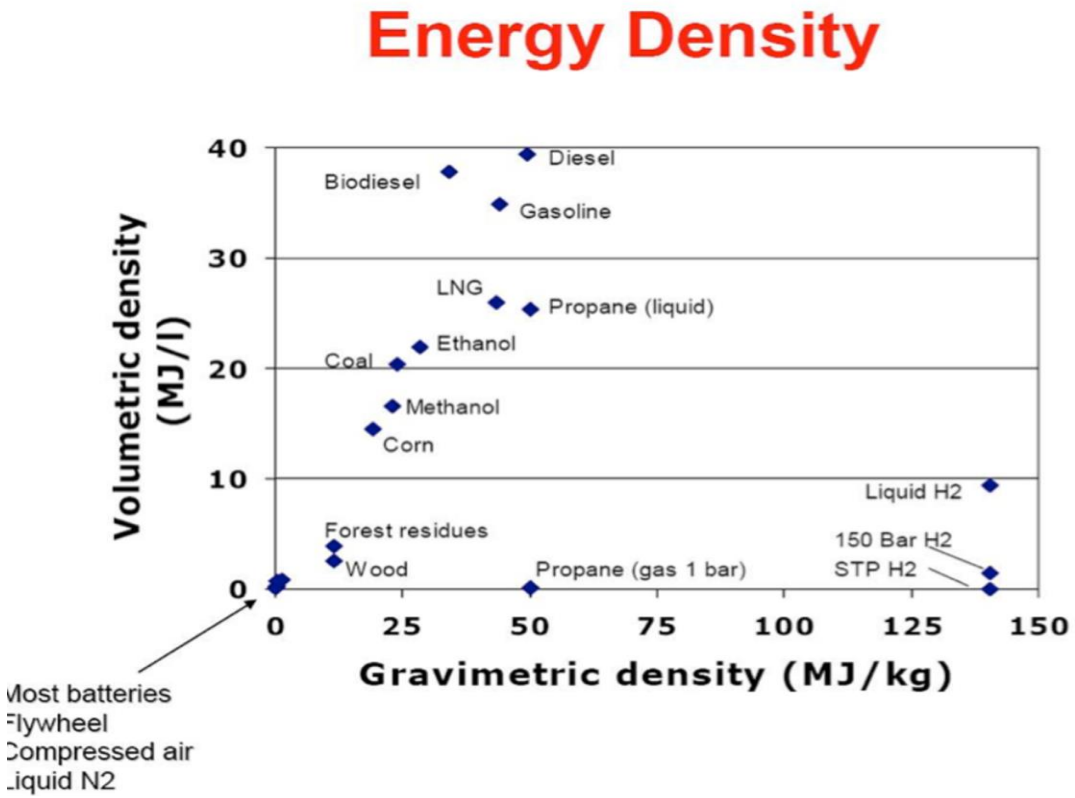
Why LNG + LBG in maritime

- The climate perspective
- No need for further major R&D steps. Can be implemented now.
- High energy denisity
- Supply and infrastructure for liquified gas to maritime is in place (in Norway)
- Increasing use of LNG in shipping
- Are there any fuel alternatives for large scale coastal fleet implementatation next 10 yrs?



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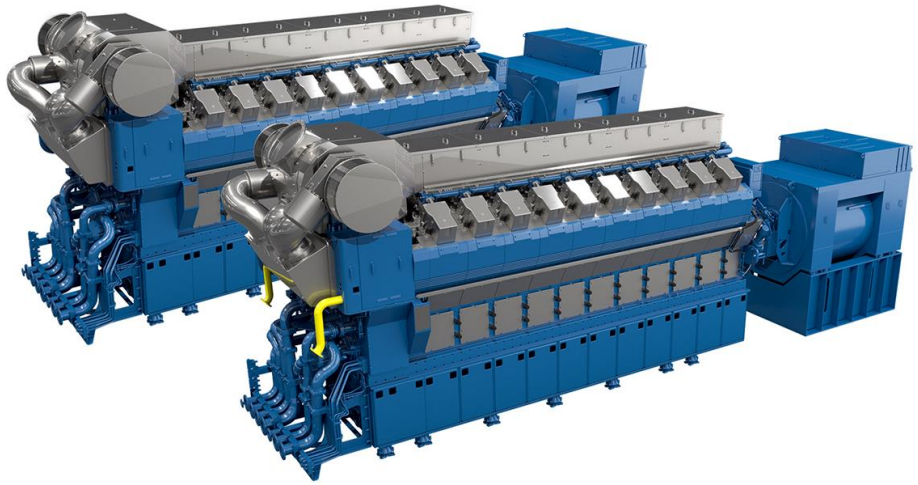
ESS + LNG/LBG is reducing the methane slip problem

Energy storage system (ESS)

+

Gas engines



- Most methane slip from new gas engines occur at variable engine load
- ESS provides peak shaving and significantly reduces the problem

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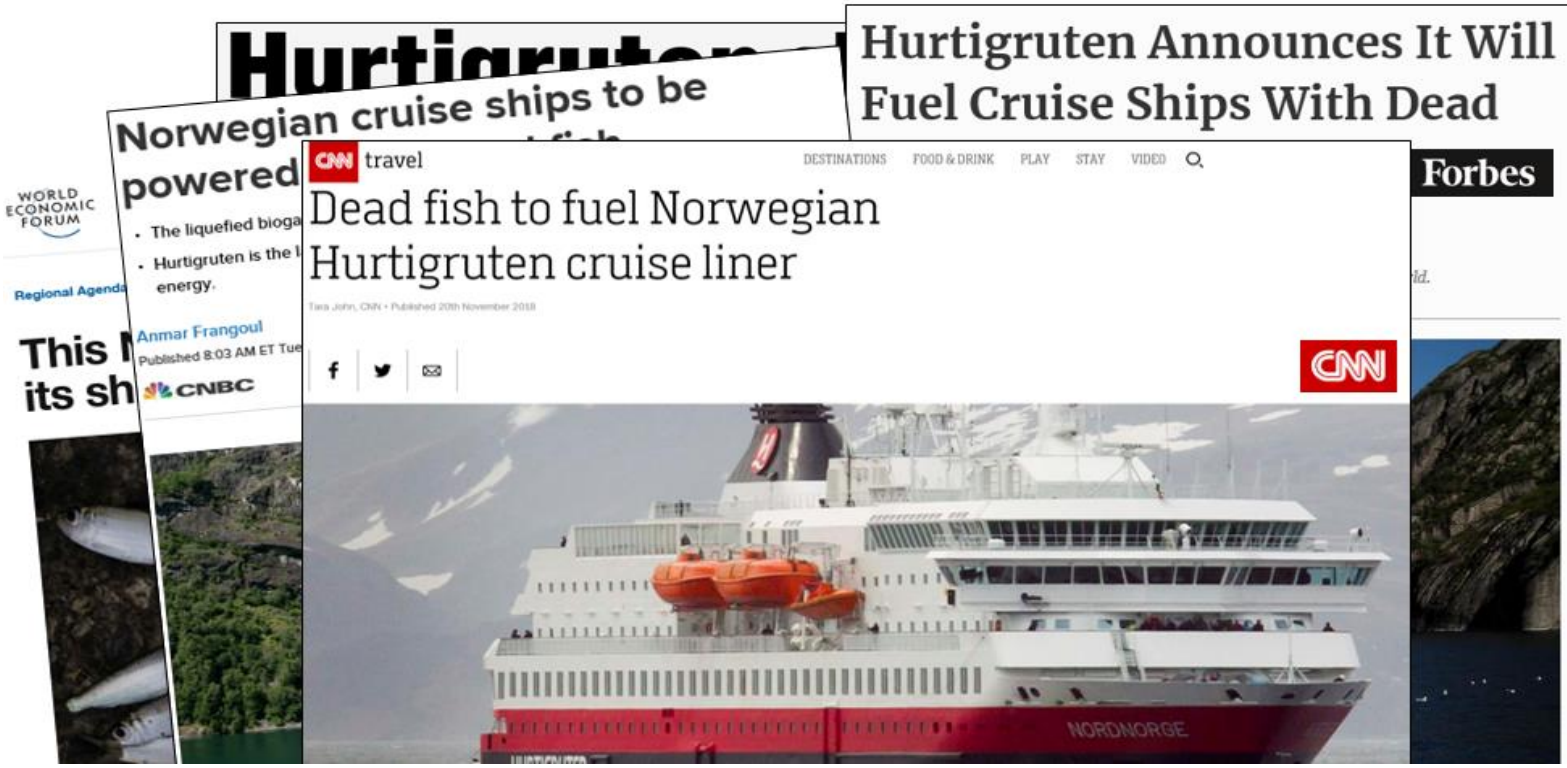
It is happening!
The Hurtigruten case

- Unique technology concept developed by Rolls Royce (Kongsberg)
- Latest generation LNG/LBG engines in combination with ESS
- All ships ready to take shore power
- Major emission reductions
- Significant financial support for the NOx Fund



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Potential for LBG in Norwegian coastal shipping

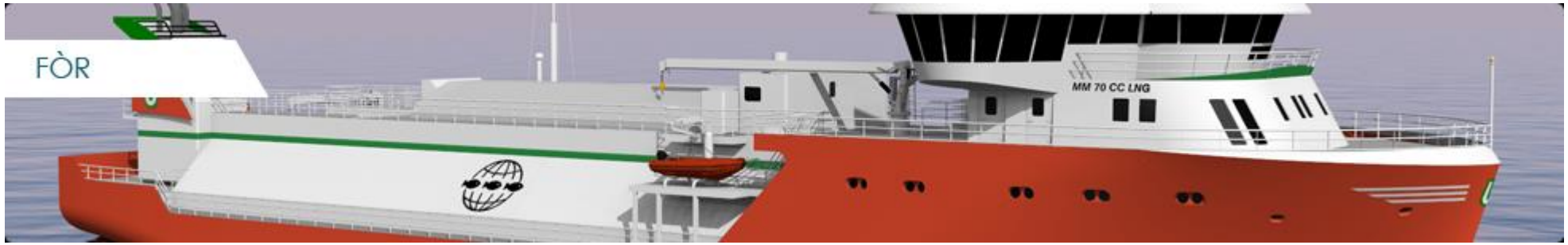
	2020	2030
Estimated LNG volumes to shipping in Norway	1800 GWh	1900-3700 GWh (growth dependant)
Estimated biogas volumes in Norway	1200 GWh	3000-5000 GWh (potential)
Estimated potential LBG volumes to shipping in Norway	100 GWh	300-2000 GWh
LBG tap-in potential	~ 10%	10-60%
LNG+LBG potential GHG reduction compared to diesel	35-40%	35-100%

SUND energy

NOx-fondet

What is needed for more to happen in maritime

- LBG volumes up and prices down (30-50% more expensive than LNG)
- Maritime LBG market must build on the back of LNG
- Continued increase in LNG volumes is needed to obtain sustainable volume levels
- Generate market pull to increase LBG volumes: Politicians must incentivize LBG, not penalize LNG. alternatively GHG emission level requirements



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Thank you for your attention!

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