Embassy of Portugal

Oslo 17th November, 2014

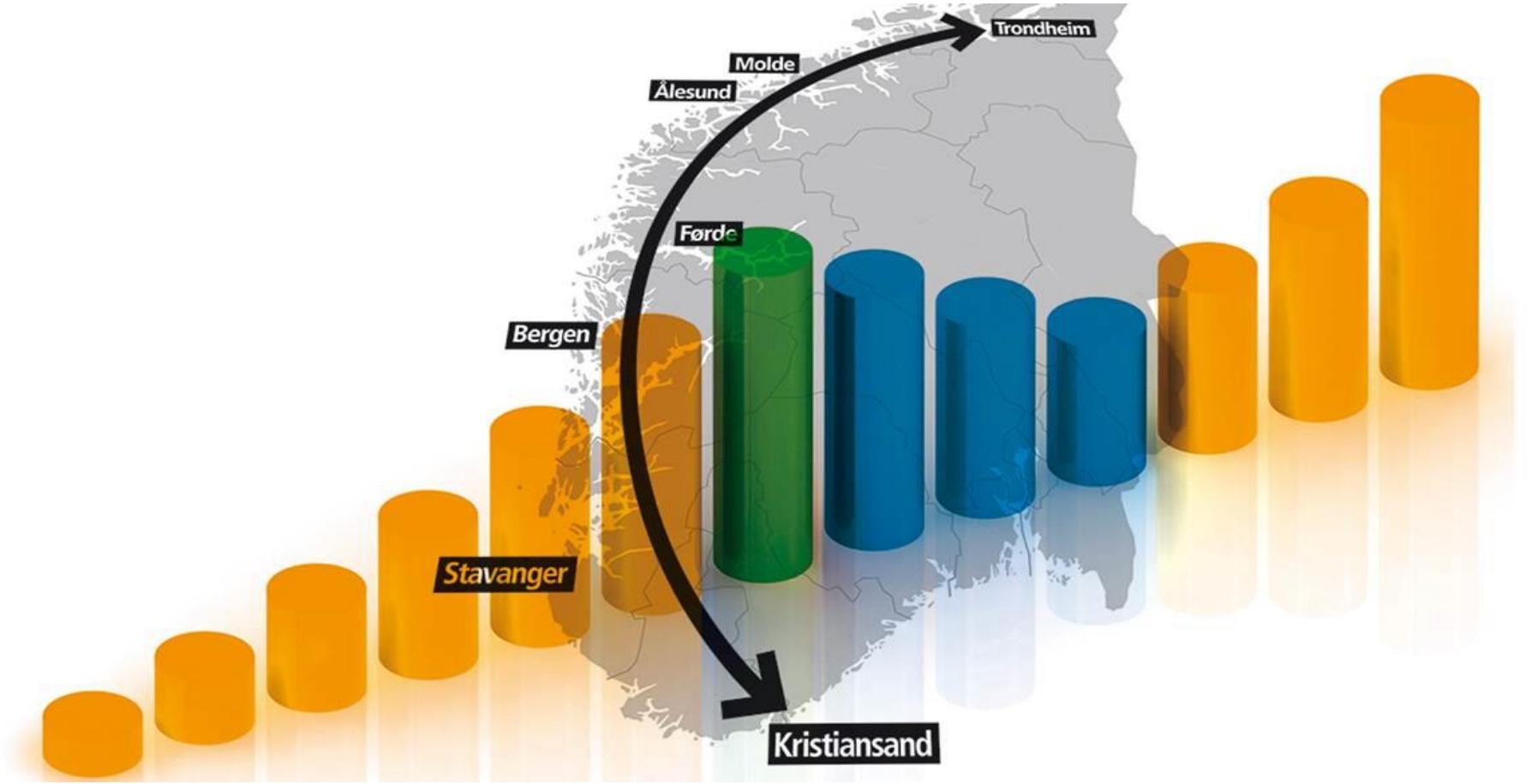
Statens vegvesen

Norwegian Public Roads Administration

Norwegian Coastal Highway Route E39

17.11.2014

Mr. Olav Ellevset, Project Manager Coastal Highway Route E39, NPRA



Statens vegvesen
Norwegian Public Roads Administration

Route E39

E39 Kristiansand-Trondheim about 1100 km

E39 Ferry Link Kristiansand-Hirtshals in Denmark

E39 connects with E45 in Aalborg, Denmark

Statens vegvesen
Norwegian Public Roads Administration

Government's and Parliament's Ambition

- Replace all ferries and upgrade corridor within 20 years
- Cost frame of NOK 150 billion (US$ 25 billion)
- From 2014

Statens vegvesen
Norwegian Public Roads Administration

Infrastructure Project

Knowledge Creation Project

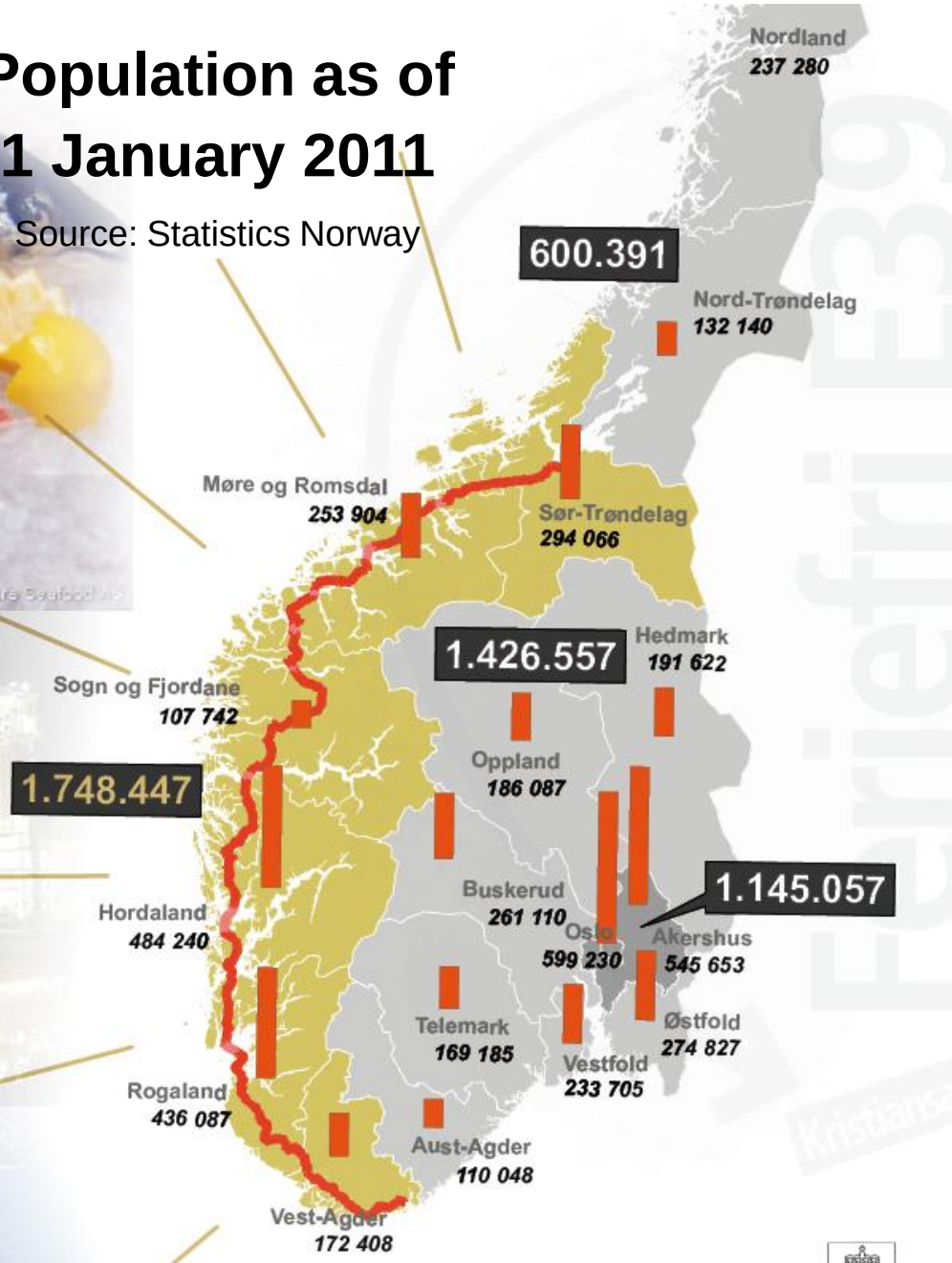
Construction Industry Development Project

Mr. Olav Ellevset, Project Manager Coastal Highway Route E39, NPRA

Population as of 1 January 2011

Source: Statistics Norway

50% of Norwegian Traditional Export Value from this area (2010)



Statens vegvesen

Statens vegvesen
Norwegian Public Roads Administration

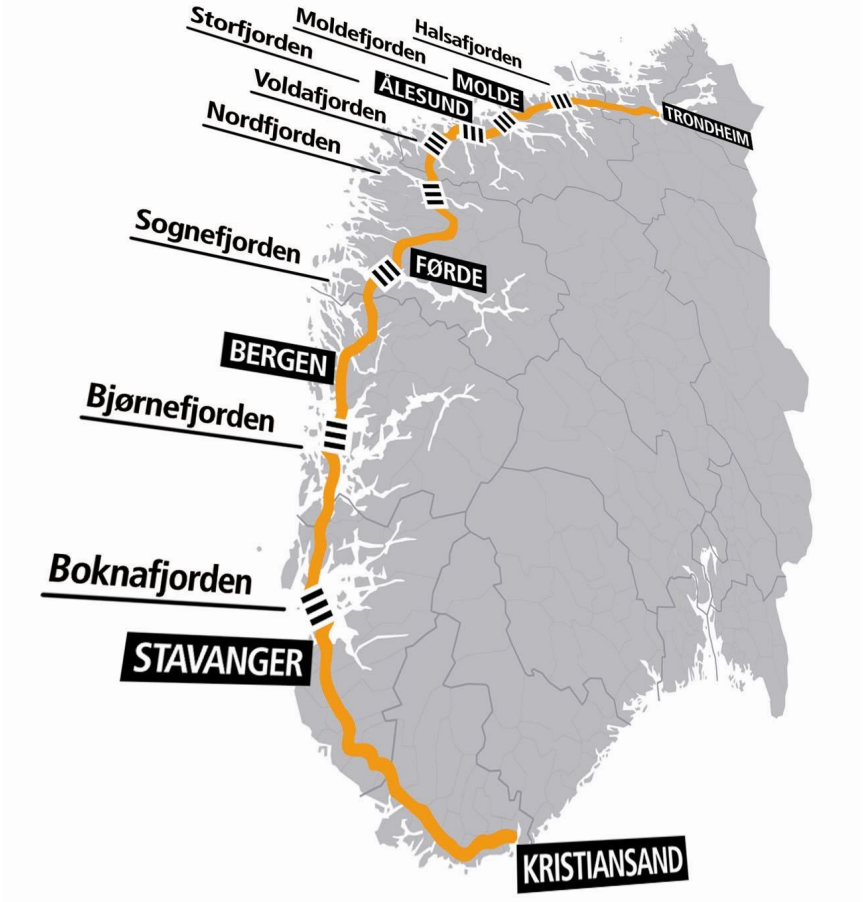
E39 Kristiansand - Trondheim

1100 km

8 Ferry links remaining

8 of 17 national ferry links

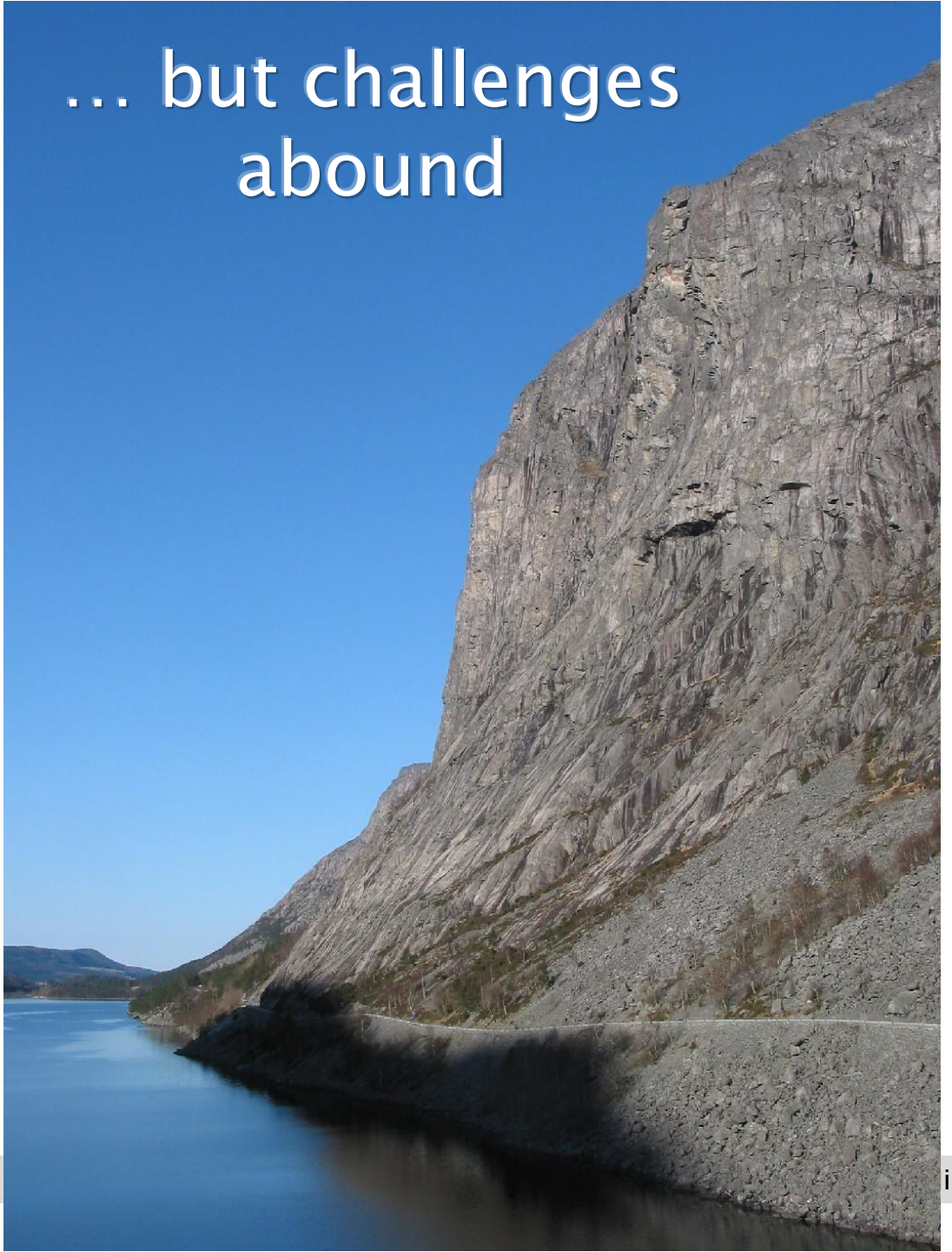
US$ 25 billion over 20 years (2014-33)



Magnificent Landscapes

Mr. Olav Ellevset, Project Manager Coastal Highway Route E39, NPRA

… but challenges abound



Statens vegvesen
Norwegian Public Roads Administration

Fjord Crossings

Key Figures (Width, Depth)

Statens vegvesen
Norwegian Public Roads Administration

Halsafjorden, 2 km, 5–600 m

Moldefjorden, 13 km subsea tunnel – 330 m + 1,6 km bridge, 5–600 m

Storfjorden/Sulafjorden, 3,4 km, 500 m

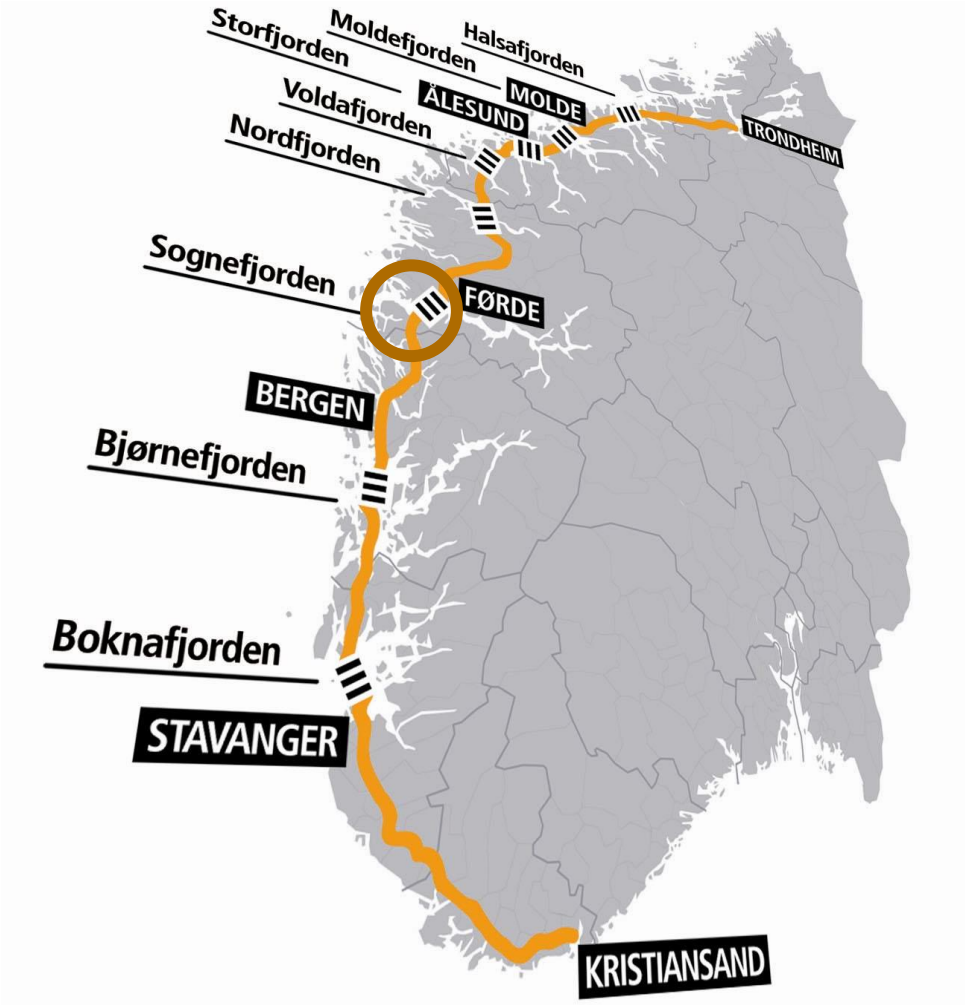
Voldafjorden, 2,5 km, 600 m

Nordfjorden, 1,7 km, 3–500 m

Sognefjorden, 3,7 km, 1250 m

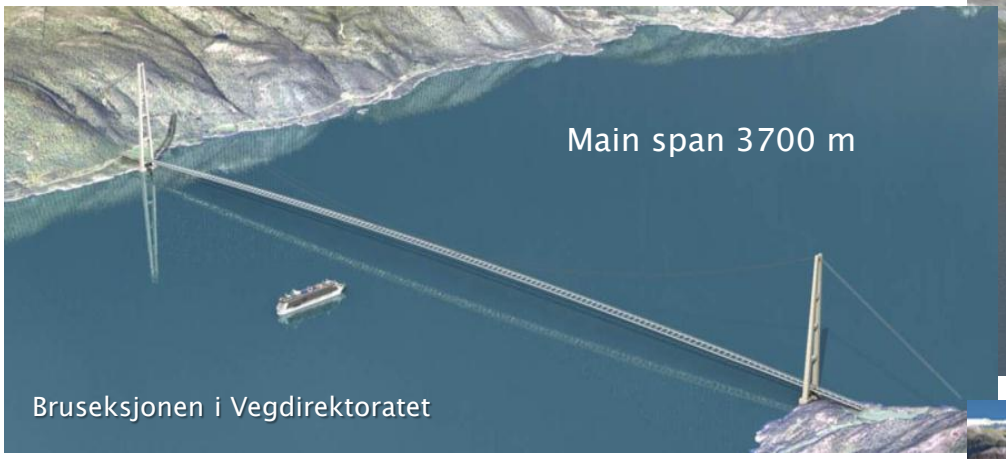
Bjørnafjorden, 4–5 km, 5–600 m

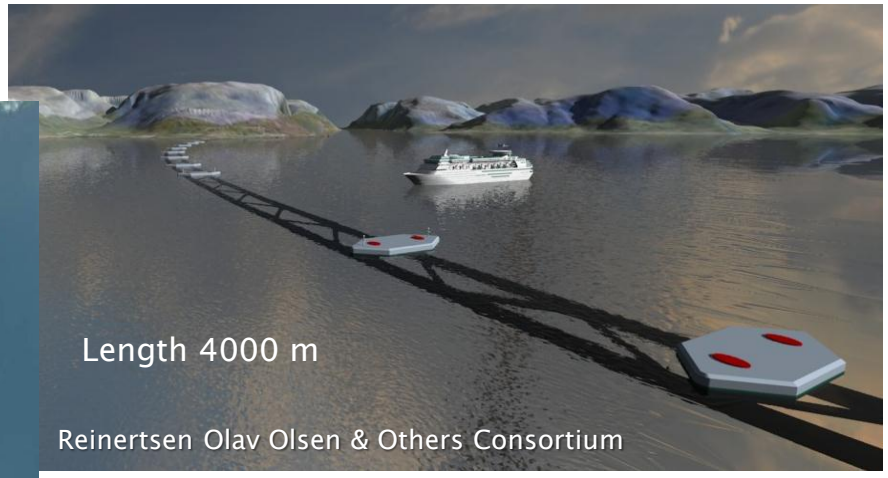
Boknafjorden, Rogfast Subsea tunnels, 26,7 km, – 390 m
(Floating bridge option, 7,5 km, 550 m depth)

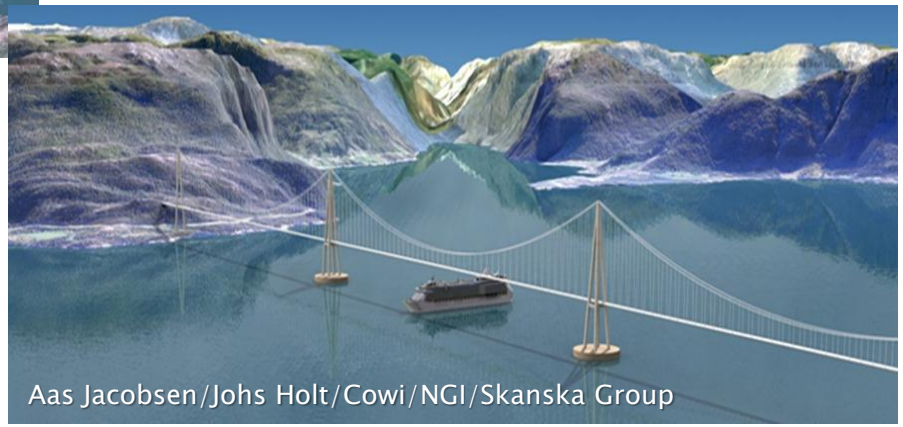


Main Concepts Sognefjord Depth 1300 m

Statens vegvesen
Norwegian Public Roads Administration







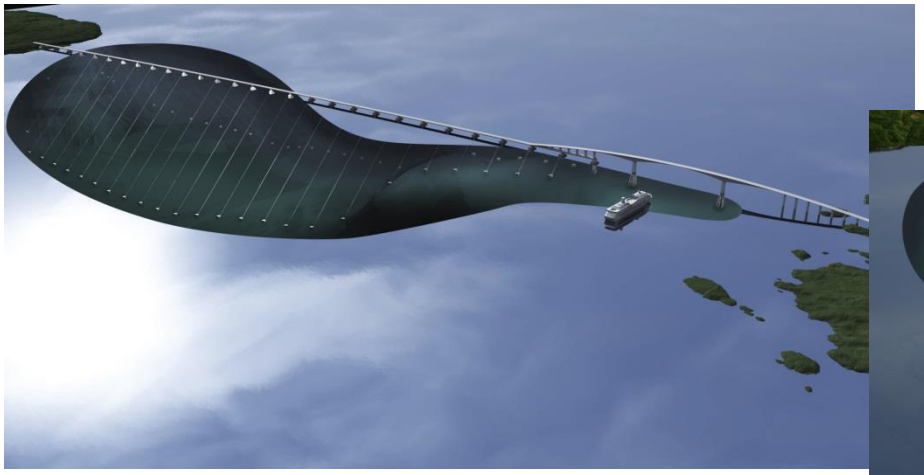
Links to Video animations:

Norwegian, short (02:30) and long (06:21)
http://www.vegvesen.no/Vegprosjekter/ferjefriE39/Film

English (06:20)
http://www.vegvesen.no/Vegprosjekter/ferjefriE39/English/Film

More Typical Depths are 5-600m

Statens vegvesen
Norwegian Public Roads Administration



Bjørnafjord Crossing
Length 4-5 km

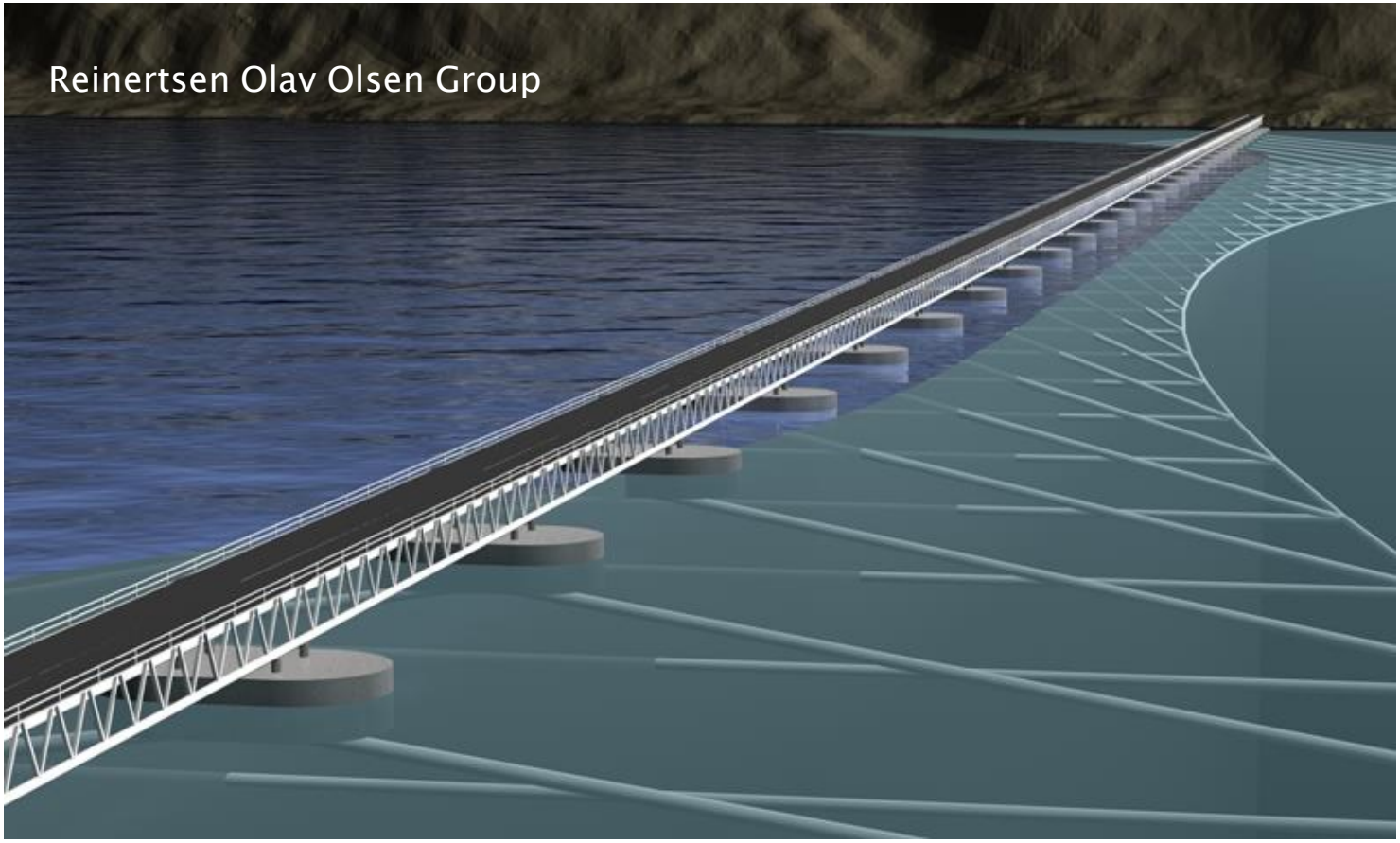
Statens vegvesen
Norwegian Public Roads Administration

LMG Marin's proposals for various fjords

Statens vegvesen
Norwegian Public Roads Administration

Fjord Crossings Component

Artificial Seabed



Statens vegvesen
Norwegian Public Roads Administration

Fjord Crossings Component

Floating Bridge and SFT anchored to Artificial Seabed

Fjord Crossings

Key Figures (Width, Depth)

Statens vegvesen
Norwegian Public Roads Administration

Halsafjorden, 2 km, 5–600 m

Moldefjorden, 13 km subsea tunnel – 330 m + 1,6 km bridge, 5–600 m

Storfjorden/Sulafjorden, 3,4 km, 500 m

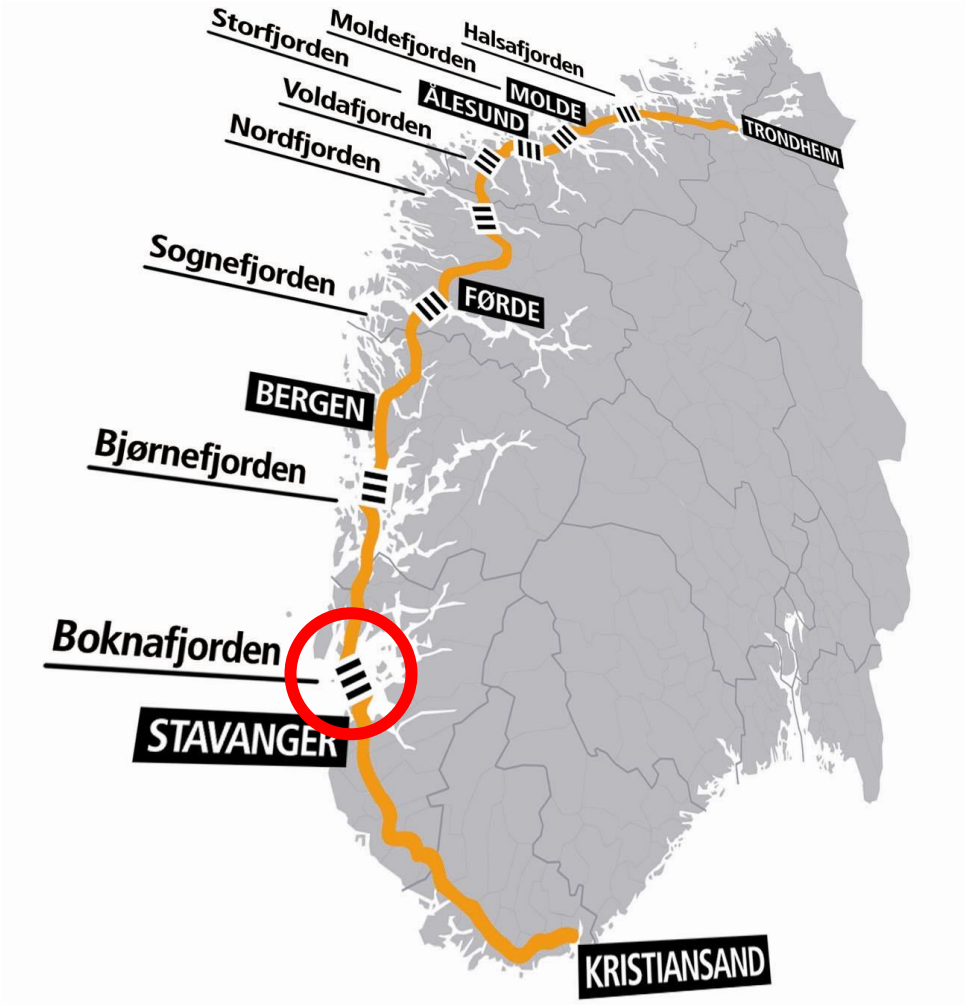
Voldafjorden, 2,5 km, 600 m

Nordfjorden, 1,7 km, 3–500 m

Sognefjorden, 3,7 km, 1250 m

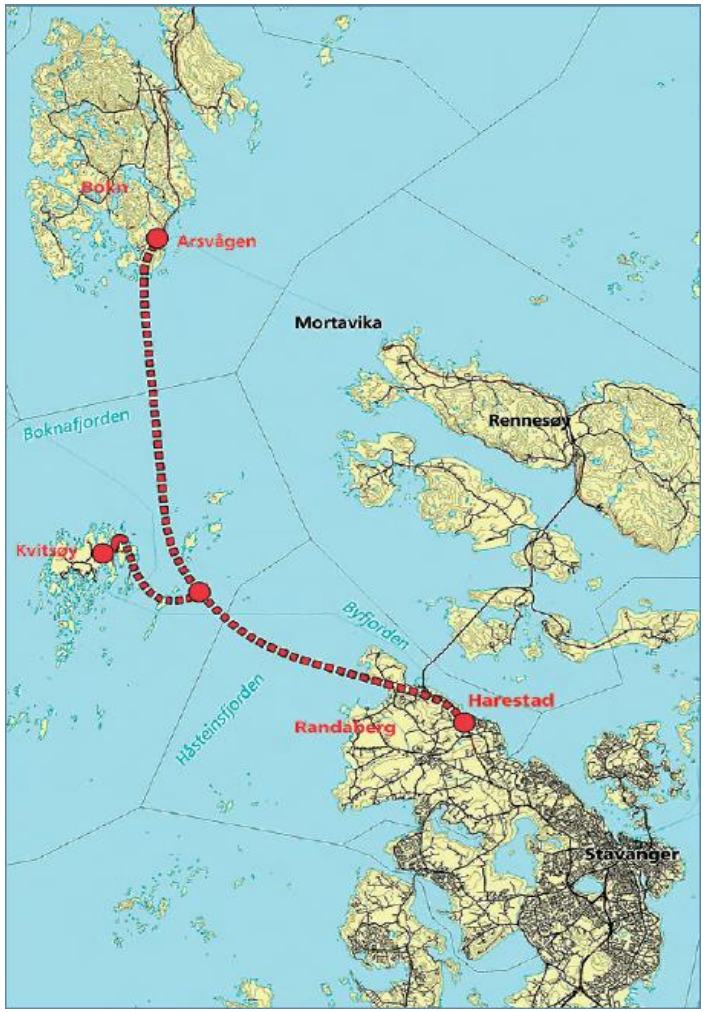
Bjørnafjorden, 6 km, 5–600 m

Boknafjorden, Rogfast Subsea tunnels, 26,7 km,
– 390 m
(Floating bridge option, 7,5 km, 550 m)



E39 Bokna Fjord (Rofast)

Statens vegvesen
Norwegian Public Roads Administration



- 27 km, world's longest road tunnel
- Gradient 5 % max.
- Depth 390 m below sea level, will become world's deepest subsea tunnel
- Two tubes (4 lanes)
- Tendering expected 2016

Statens vegvesen
Norwegian Public Roads Administration

Bridge Concept for The Boknafjord in Rogaland

Statens vegvesen
Norwegian Public Roads Administration

Recent Developments–Offshore Structures

Ekofisk tank:
70 m depth (1973)

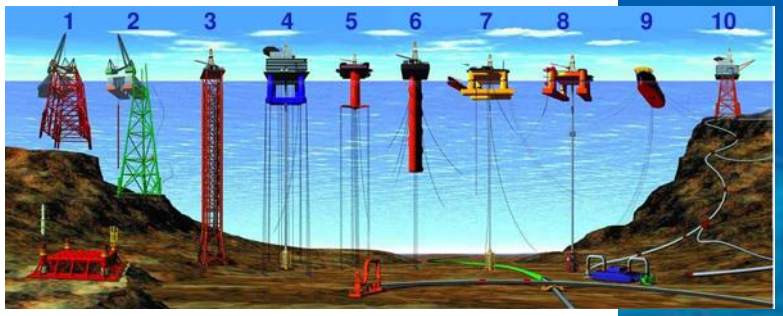
Troll platform:
303 m depth (1995)

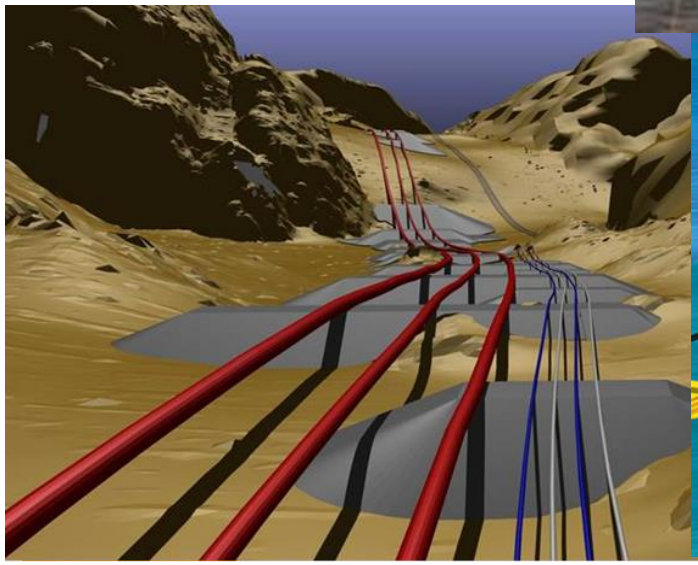
Buoyant platforms (TLP) moored at depths of more than 1500 m

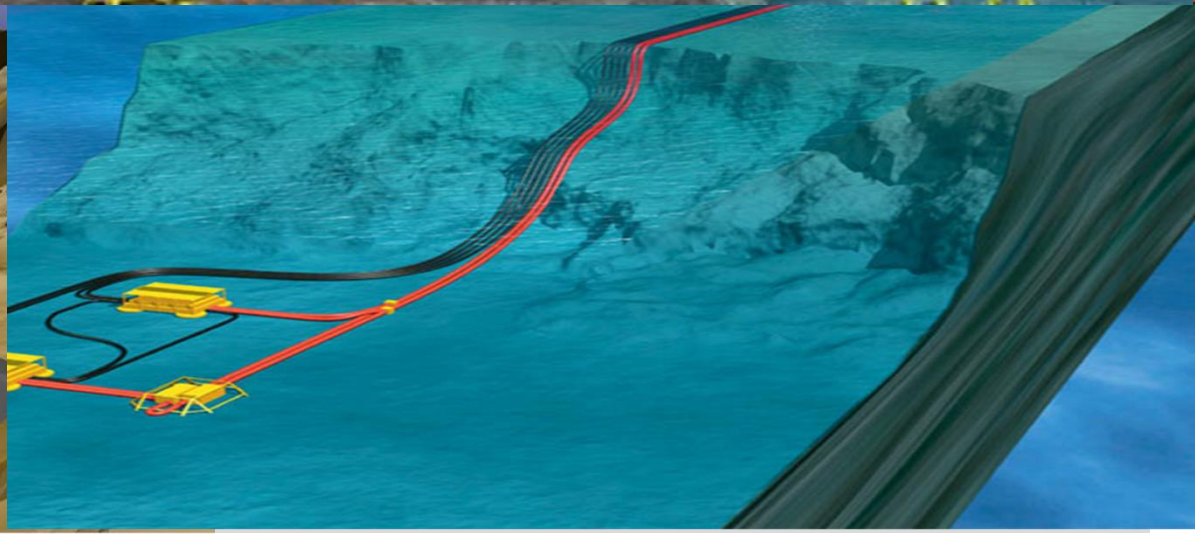
Statens vegvesen
Norwegian Public Roads Administration

Research & Development

Technology does not come by its own !







Statens vegvesen
Norwegian Public Roads Administration

Research and Development (R&D) Programme

- To build infrastructure with improved life time, less life cycle costs, less accidents, and less emissions
- Forefront of technology, create and utilize last and updated knowledge
- Service Life Design up to 200 years
  - fib Bulletin No. 34: Model Code for Service Life Design
- Prepare corridor for vehicles powered by electricity or hydrogen

Fjord Crossings

Key Figures (Width, Depth)

Statens vegvesen
Norwegian Public Roads Administration

Halsafjorden, 2 km, 5–600 m

Moldefjorden, 13 km subsea tunnel – 330 m + 1,6 km bridge, 5–600 m

Storfjorden/Sulafjorden, 3,4 km, 500 m

Voldafjorden, 2,5 km, 600 m

Nordfjorden, 1,7 km, 3–500 m

Sognefjorden, 3,7 km, 1250 m

Bjørnafjorden, 6 km, 5–600 m

Boknafjorden, Rogfast subsea tunnels, 27 km, – 390 m
(Floating bridge option, 7,5 km, 550 m depth)

The Bjørnafjord Crossing

The R&D Needs are Obvious

Suspension bridge option
with two towers on floating platforms/TLPs

Current Activities Bjørnafjord

- Preliminary design Floating bridge Bjørnafjord
  - Aas-Jakobsen, Johs Holt, Cowi & Others
- Preliminary design Submerged floating tunnel
  - Bjørnafjord: Reinertsen, Olav Olsen, Norconsult & Others
- Assistance with developing the TLP-concept for suspension bridge on floating foundations:
  - TDA A/S, Aker Solutions
- Risk analyses for ship collisions: SSPA Sweden AB
- Data collection:
  - Wind: Kjeller Vindteknikk
  - Currents and waves: DHI Norway
  - Seismic and sediments

Statens vegvesen
Norwegian Public Roads Administration

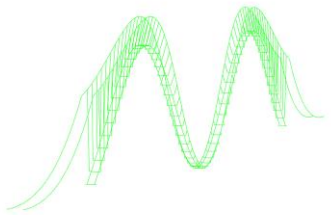
Long Span Suspension Bridges Wind Tunnel Testing

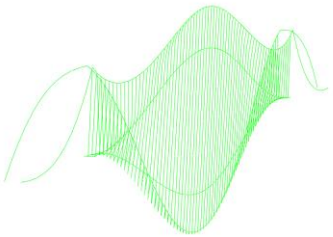
- Julsundet Suspension bridge
  - to be completed 2014

- Halsafjorden Suspension bridge
  - to be completed summer 2015

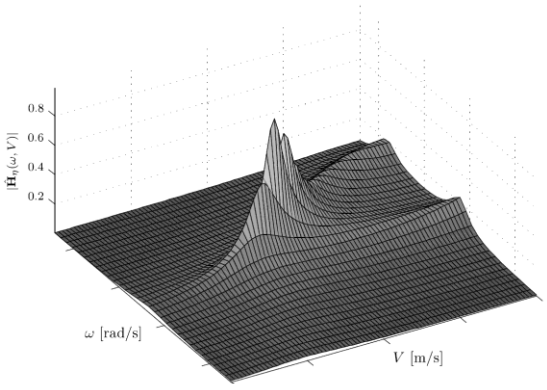
At Copenhagen Wind Tunnel (Sven Ole Hansen ApS, DK)

Halsafjorden – Eigen-frequencies and Flutter





Mode	Frequency [Hz]	Period [T]
HS1	0.039	25.67
HA1	0.074	13.46
VA1	0.084	11.91
VS1	0.103	9.74
HS2	0.115	8.66
VS2	0.138	7.25
TA1	0.156	6.40
VA2	0.157	6.37
TS1	0.158	6.32



$$\hat{E}_\eta(\omega,V)=\left\{\mathbf{I}-\boldsymbol{\kappa}_{ae}-\left(\omega\cdot diag\left[\frac{1}{\omega_i}\right]\right)^2+2i\omega\cdot diag\left[\frac{1}{\omega_i}\right]\cdot(\boldsymbol{\zeta}-\boldsymbol{\zeta}_{ae})\right\}$$

$$\left|\det\left(\hat{E}_\eta(\omega,V)\right)\right|=0$$

European Commission

EC White Paper 2011

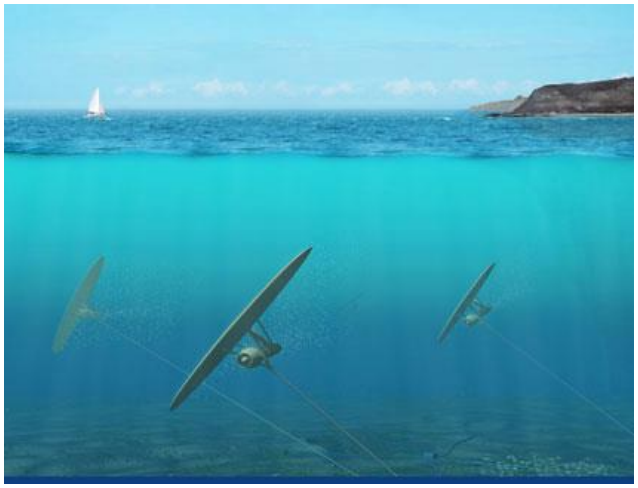
Among the
Key goals by 2050:

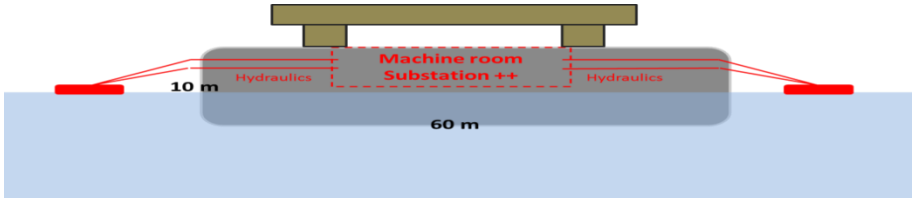
- No more conventionally-fuelled cars in cities
- 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions
- A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport
- All of which will contribute to a 60% cut in transport emissions by the middle of the century.

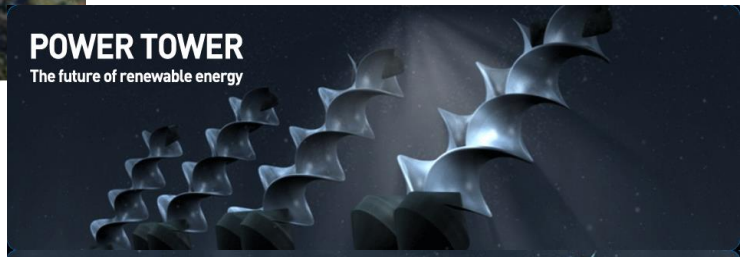

Famous
Atlantic Road

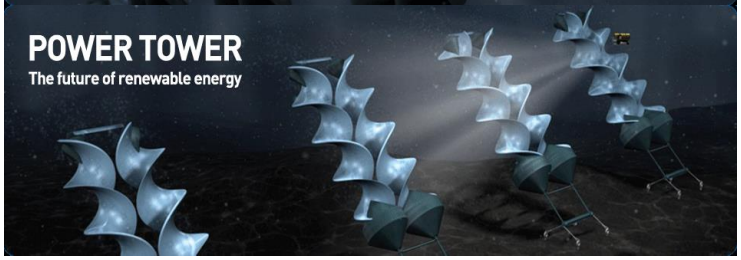
Statens vegvesen
Norwegian Public Roads Administration

Energy Component
Contributing to Meeting Climate Goals ?







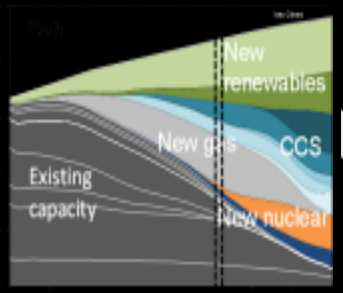


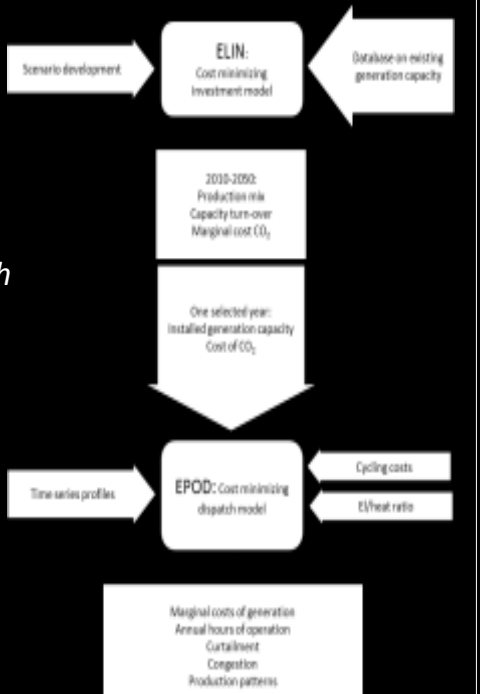
Potentials look larger than previously anticipated !

Project 11

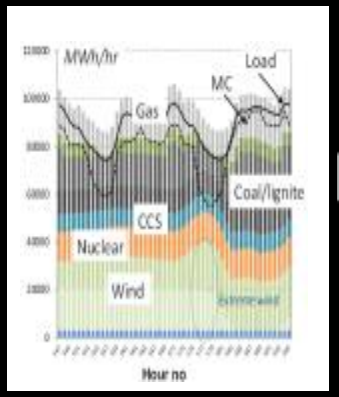
The E39 as a renewable European electricity hub

ELIN – long-term investments





EPOD – hourly dispatch



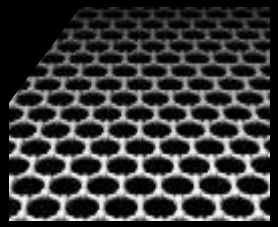
Project 13

Graphene feasibility and foresight study for road infrastructure

Roadmap for how graphene can be utilized for Statens Vegvesen and the E39 Coastal Highway Route initiative

Roadmaps for ICT, and electronics exists, but for road infrastructure this will be the first

- Graphene-based composites
- Reinforcement of concrete to increase tensile strength and ductility
- New and revolutionary structural engineering paradigms
- Super capacitor based systems for inductive charging of electric vehicles
- Graphene-based solar panels for production of electricity
- New sensor systems and new electronics concepts

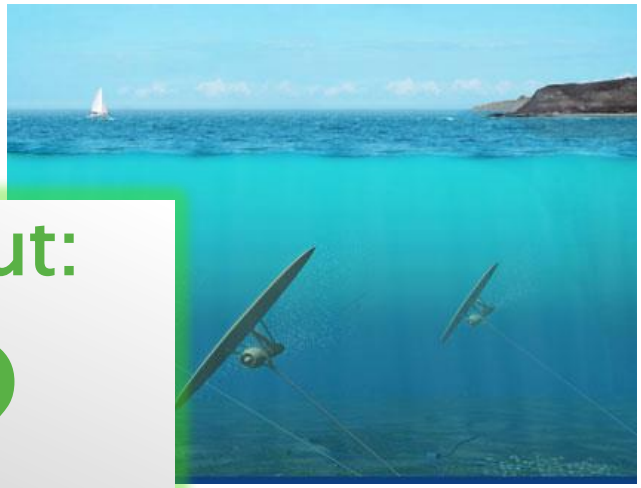


2020
Composites available for R&D needs
Proof of concept of sensor platform

2030
Composites in XXX road application
Sensor in XXX road application

Statens vegvesen
Norwegian Public Roads Administration

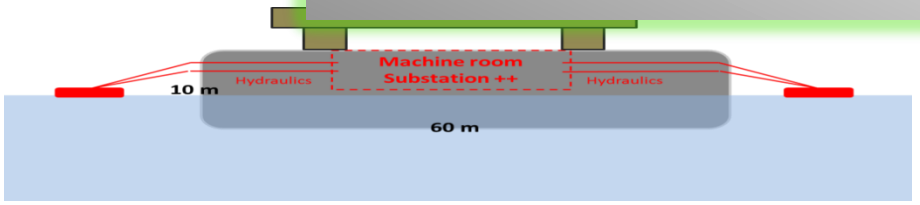
E39 Energy Component
Contributing to Meeting Climate Goals ?



May start talking about:

- Passive Roads
- Plus Roads, or
- Power Roads

?



Potentials look larger than previously anticipated !

Main Contracting Approaches

Statens vegvesen
Norwegian Public Roads Administration

Road Section Type	Contracting Approach
Fjord Crossings	Design-build (DB)
Road Section w/many structures	Design-build (DB)
Upgrading and new sections along existing corridor	Bid-Build (BB) or Design-bid-build (DBB), w/Improvements Detailed design

Statens vegvesen
Norwegian Public Roads Administration

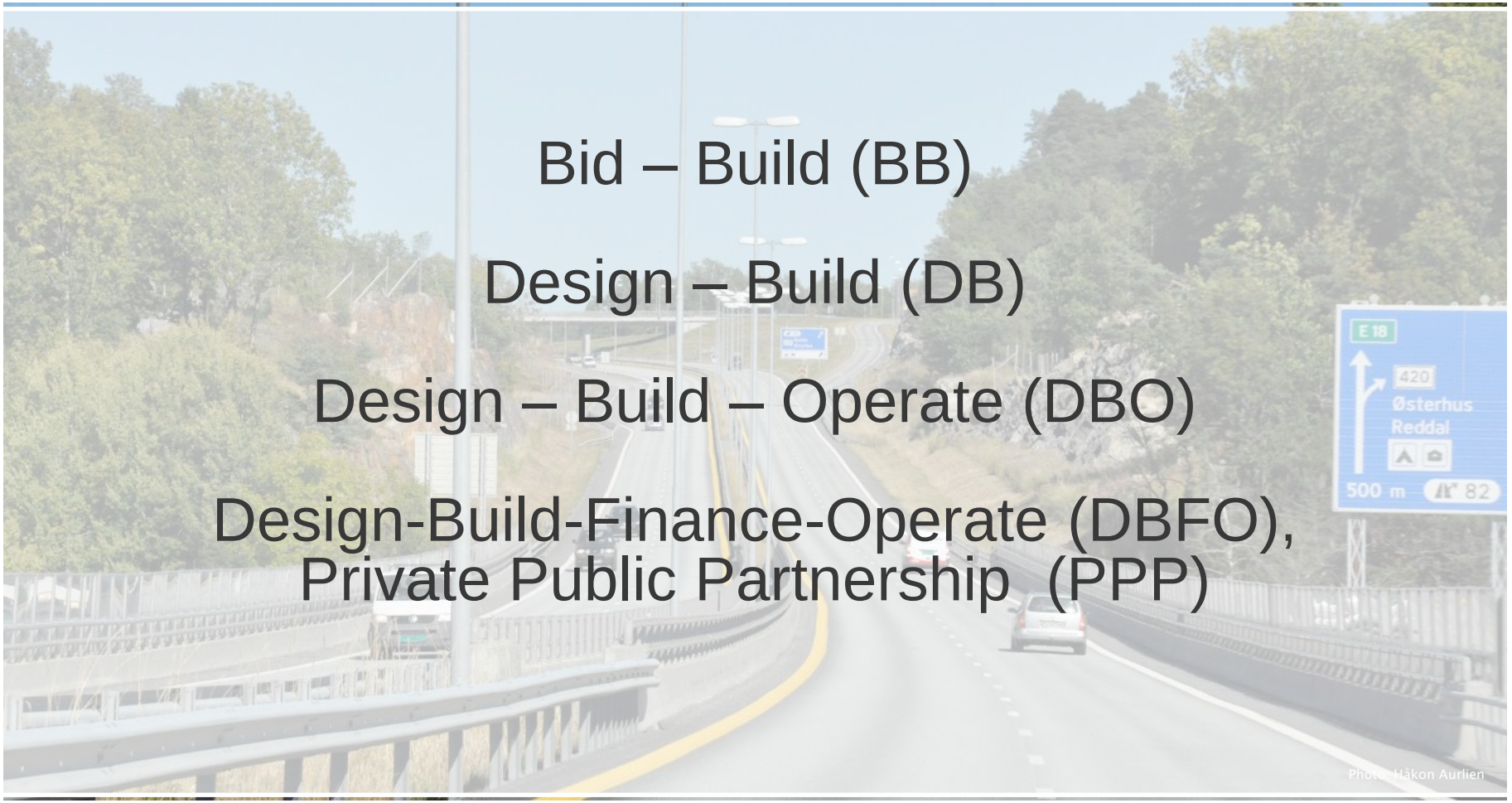
Implementation

Different types of Contracts

- Size of contracts
  - < Euro 100 million to >1 billion
  - Up to 100 kilometer
  - Content and duration to allow innovation, R&D, and industrialisation for larger contracts
- D-B w/Competitive dialogue, Alliance- or comparable types of contracts with substantial content of dialogue to find optimal Technical solutions and sort out Risk distribution
- Risk well balanced between Client and contract Consortium
- Tendering approach to utilize joint competence of client, consultants and contractors when beneficial

Different Project Models used in Norwegian Road Projects

Statens vegvesen
Norwegian Public Roads Administration



Bid – Build (BB)

Design – Build (DB)

Design – Build – Operate (DBO)

Design-Build-Finance-Operate (DBFO),
Private Public Partnership (PPP)

Photo: Håkon Aurlien