Welcome to

Statnett's R&D Conference 2019

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Innovative Technology Session

Introduction to Innovative Technology	Oddgeir Kaspersen	Statnett
Can we use aluminum for our towers?	Andreas Istad Lem	Statnett
Can we build 420 kV tower in composite?	Ivar Brovold	Statnett
Can robots help improve safety?	Livia M. Dickie	Statnett
Is digital substation a way towards next transition?	Rannveig Løken, Nargis Hurzuk	Statnett
Can we get rid of our icing problems?	Øyvind Welgaard	Statnett

InnovativTeknologi
Innovative Technology

Statnett R&D Conference 2019

Oddgeir Kaspersen
Oslo, 02.04.2019

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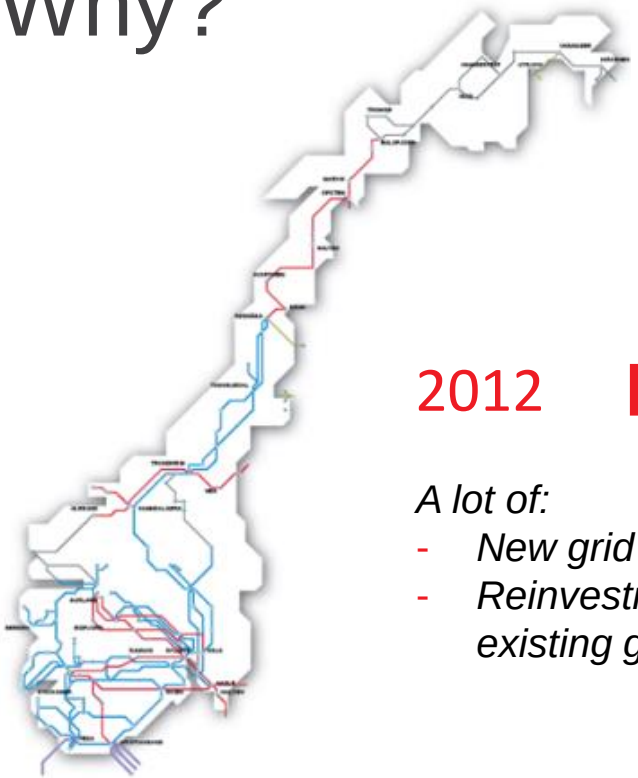
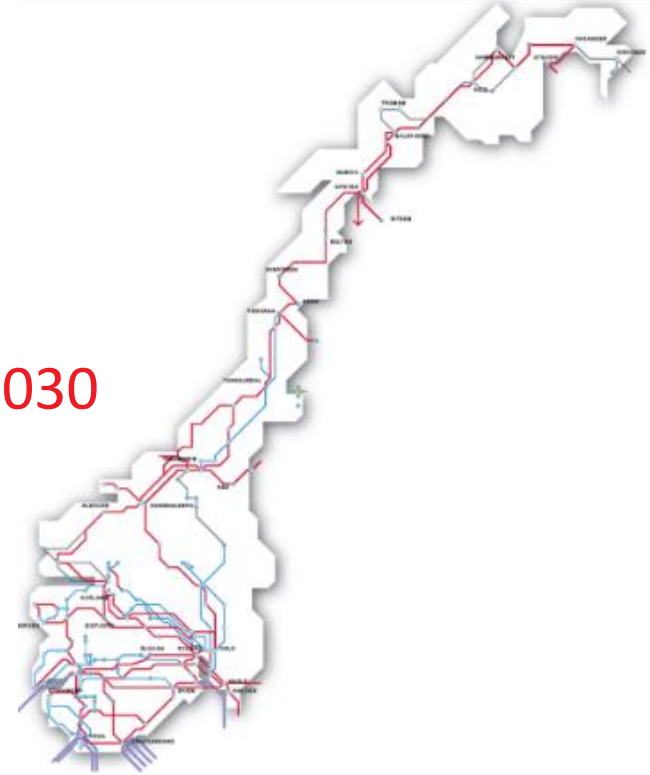
Why?



2012

2030



A lot of:

- *New grid*
- *Reinvestment in existing grid*

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Goal?

Develop technology, methods and **know-how** that yield

20 % increased safety
20 % faster construction time
20 % cost reduction

for **construction** of overhead lines, cables and substations

Lean Line

Lean Substation

Lean Cable

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Any challenges?

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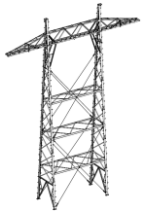
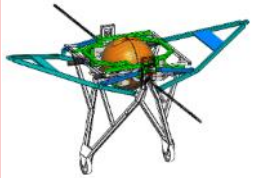
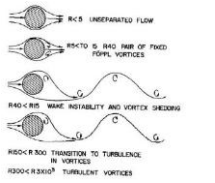
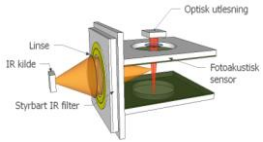
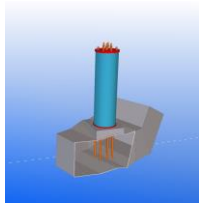
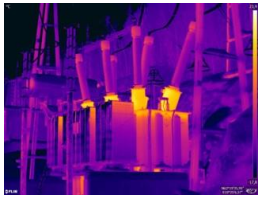
What has been done?

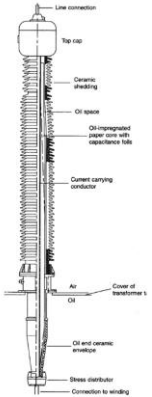
Aluminum tower	Composite tower	Installing AWM using a robot	Digital Substation	ICEBOX
				











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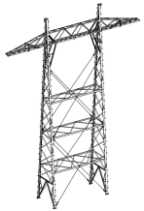
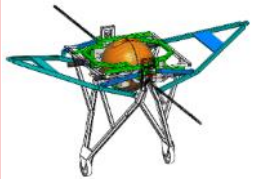
Enjoy!

Aluminum tower	Composite tower	Installing AWM using a robot	Digital Substation	ICEBOX
				

Light-weight transmission towers

Can we use aluminium for our transmission towers?

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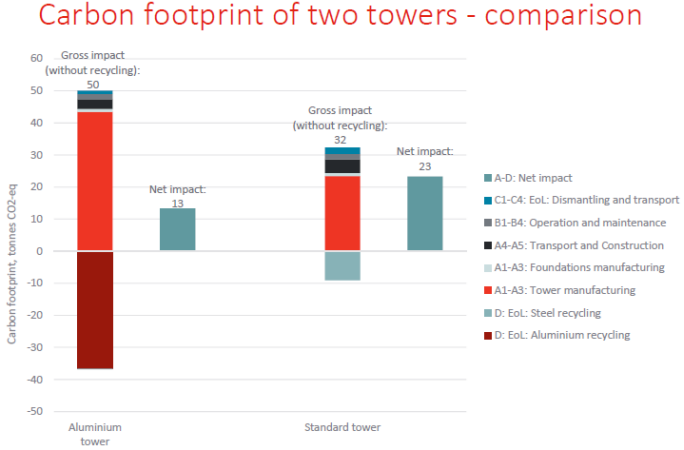
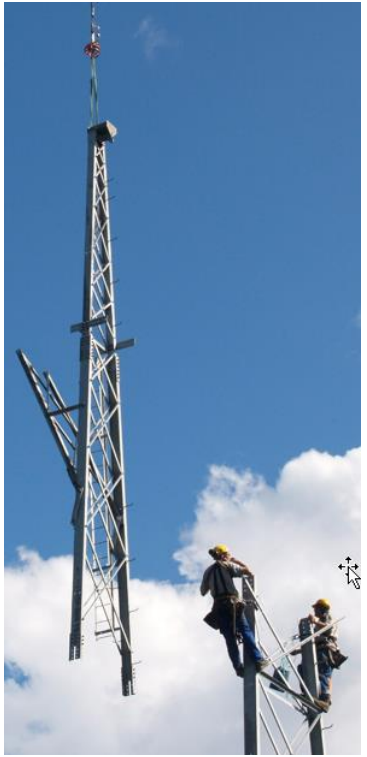
Oslo, 02.04.2019

Why light-weight towers?

- HSE
- Less use of helicopter
- Life cycle emissions





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Can we use aluminium towers?

- But at what price?
  - Material cost
  - Manufacturing
  - Tower erection
  - Maintenance

Life cycle costs

Bugatti la voiture noir

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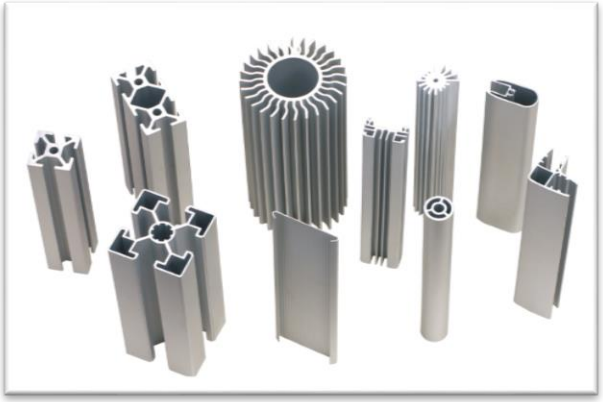
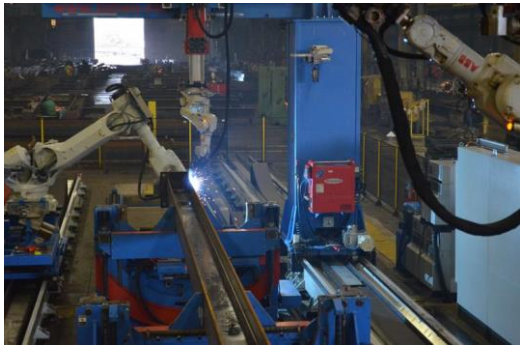
A few words about aluminium

- Pros:
  - Light (1/3x)
  - Strong
  - Non-corroding
  - Easy to shape
  - Recyclable
- Cons:
  - Expensive (3x)
  - Low stiffness (1/3x)
  - Poor weldability
  - VIV

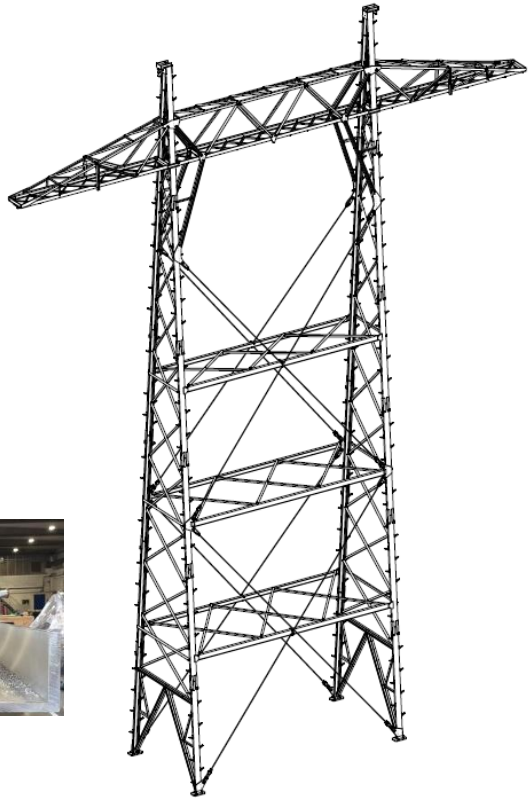


Material cost

- Raw material price (3x)
- Weight efficient design
- Smart beam profiles
- Large scale production

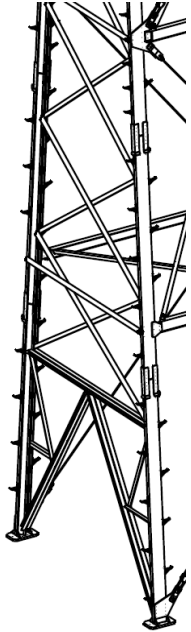


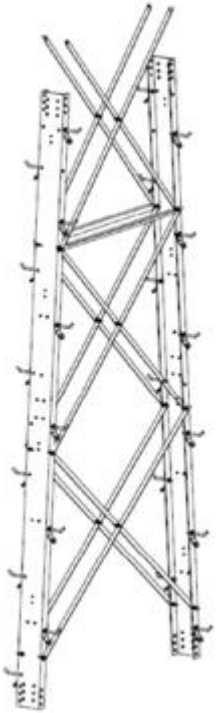
Prospect Steel

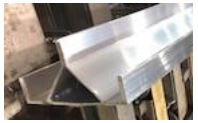


Manufacturing

- Smart use of welding
- Simple cutting and drilling operations
- Few members
- Automation

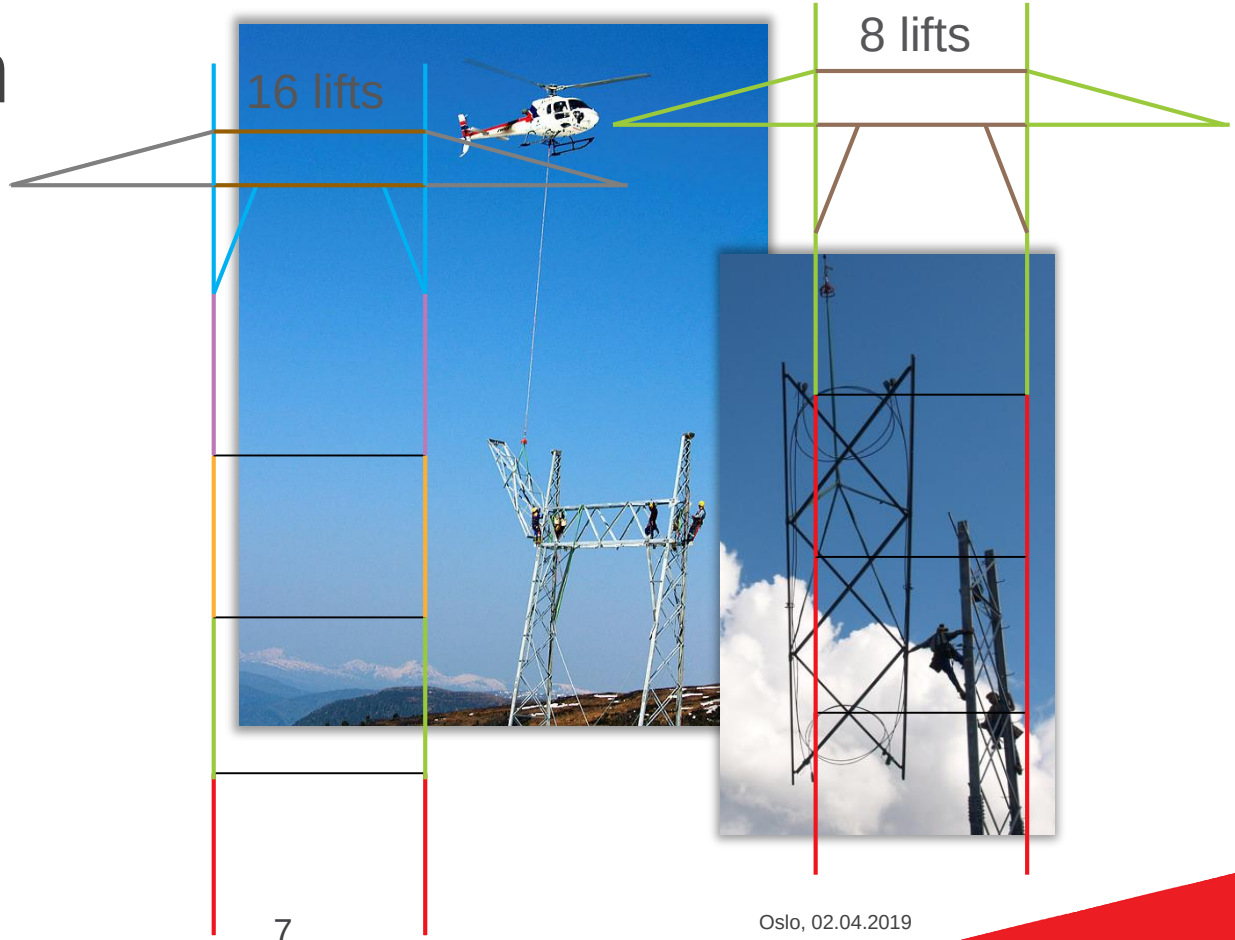






Tower erection

- Lower weight
- Module design
- Good handling
- Docking?



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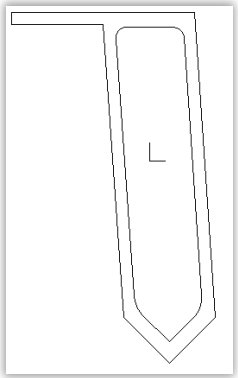
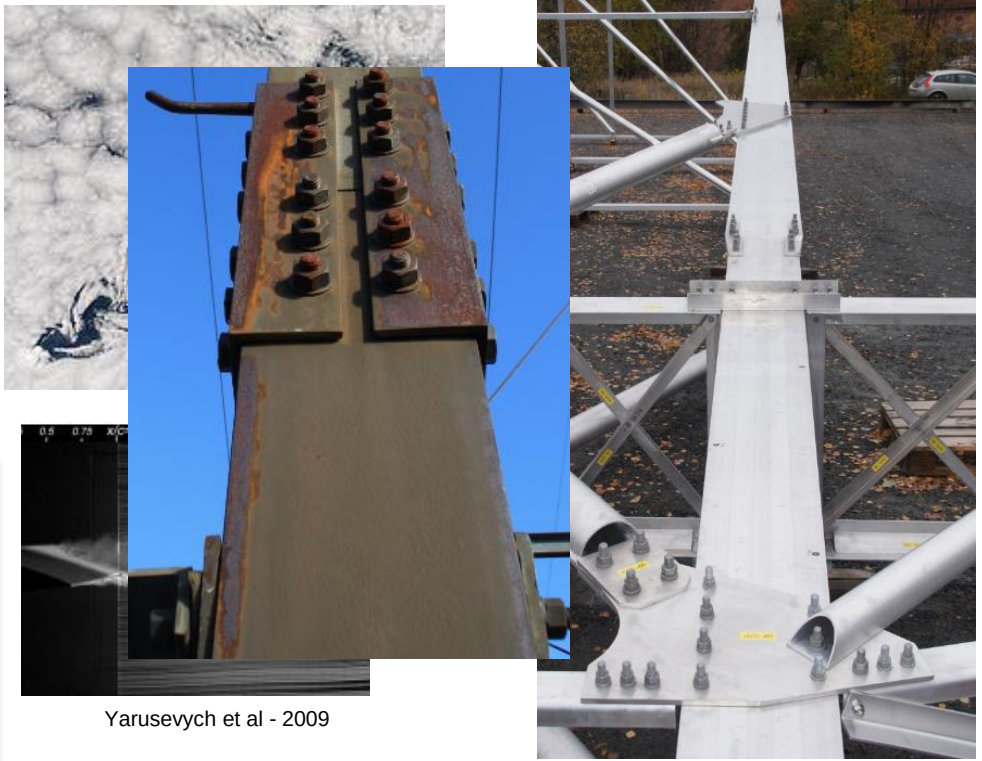
Maintenance

- No corrosion
- Design to avoid vibrations
- Easy to replace parts
- Easy to climb





Yarusevych et al - 2009

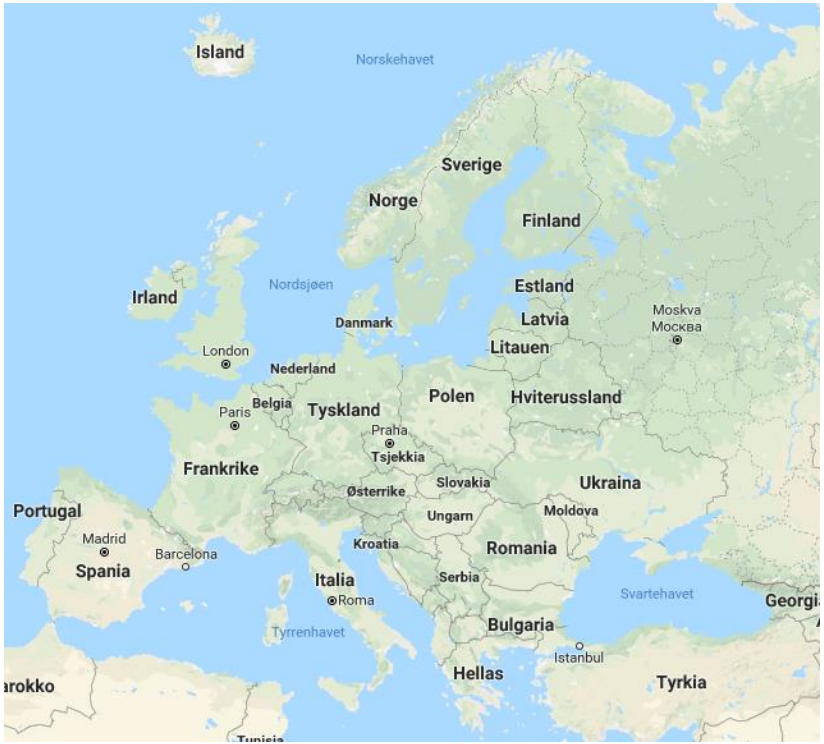
Conclusions so far

Full scale tower test

- Sucessful!
- Proof of design

Price still uncertain

- Sourcing underway
- Immature market
- Chicken or the egg



What now?

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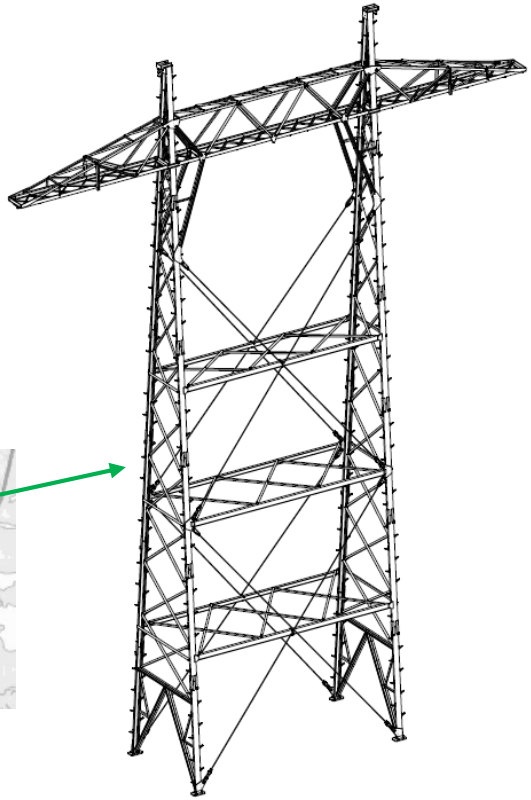
Pilot tower

- Kobbvatnet – 67.5º nord
- Moderate loads
- Monitoring



Future projects

- If the cost is right
- Haugalandet (~100)
- Aurland-Sogndal (~30)
- …

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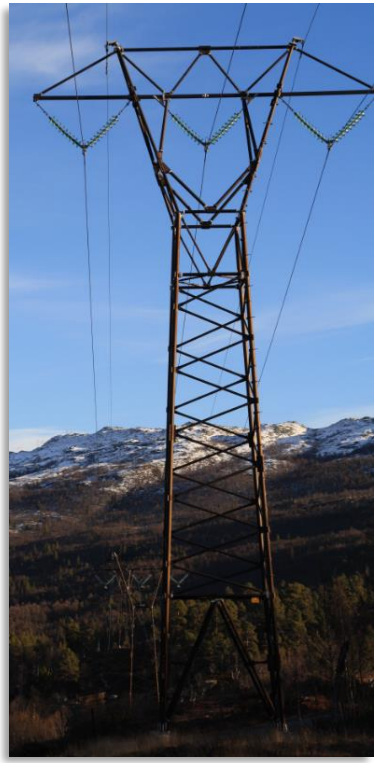
Aluminium towers in Norway today



Thank you for your attention!

Can we build 420 kV towers in composite?

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Oslo, April 2nd 2019

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Tower erection in Norway

- Erection with helicopter
  - Capacity 1000–1100 kg
  - 15-20 trips to erect one tower
- Standard lattice steel tower designed for helicopter erection

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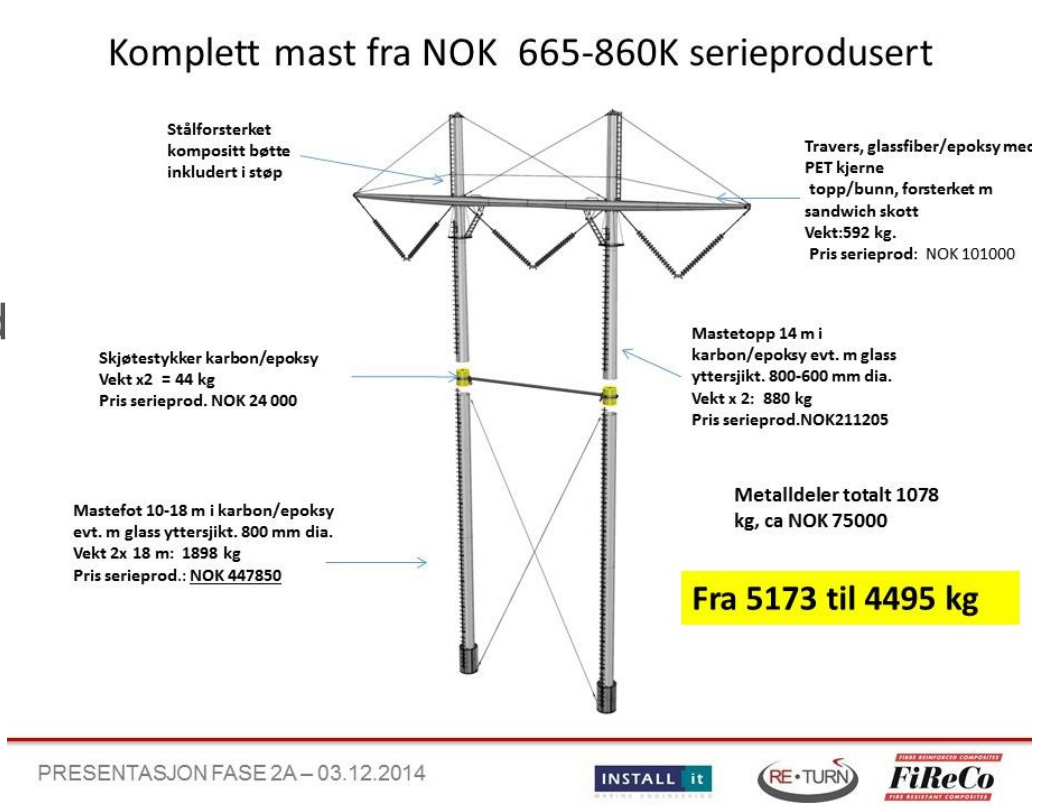
Why composite

- High strength to weight ratio
- Non-corrosive
- Less maintenance
- Visual impact
  - Few elements
  - "Simple/plain" design

- Fewer helicopter lifts will improve safety for workers (4-5 trips?)

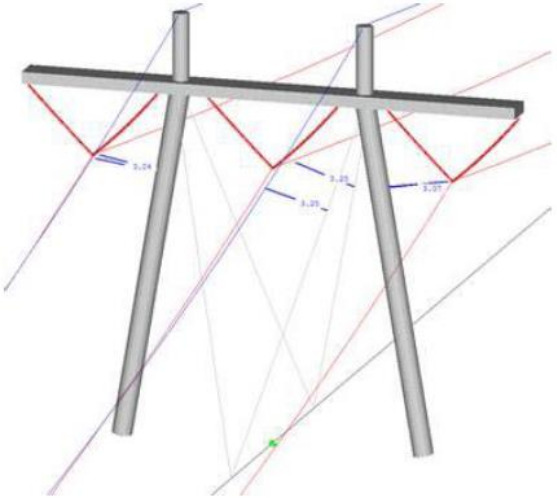
History

- Re-Turn
  - 2013-2015
  - Only design – not connected to production process
  - Different materials
    - Carbon fibre
    - Glass fibre
    - Epoxy
  - Design / weight / price!



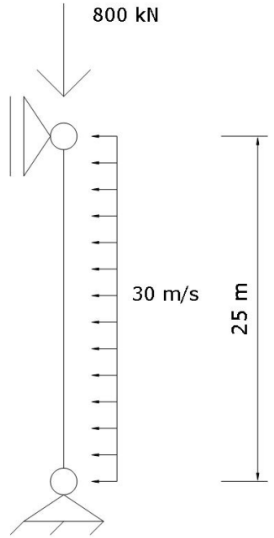
History

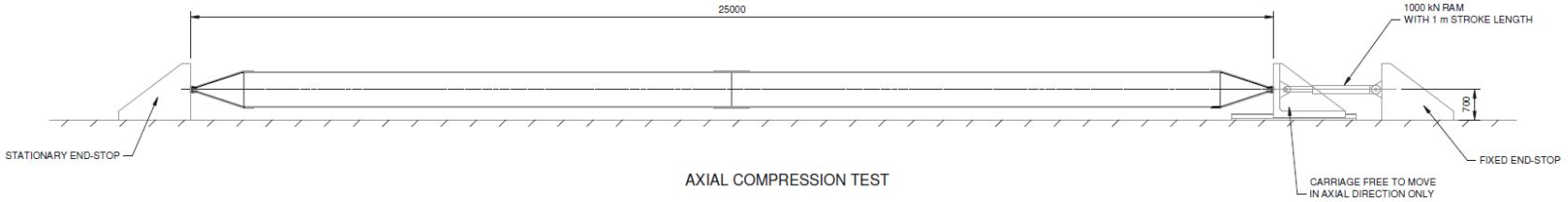
- CSUB 2016-2018 Consortium: CSUB/Flowtite/Fibre Content/Amiblu
  - Continuous filament winding process – glass fibre and polyester
  - Legs for externally guyed tower (limited use)



History

- Test setup
  - Wind load simulated by the weight of the pipe
  - Hydraulic cylinder with a capacity of 1200 kN
  - Simply supported with a spherical bearing at each end





AXIAL COMPRESSION TEST

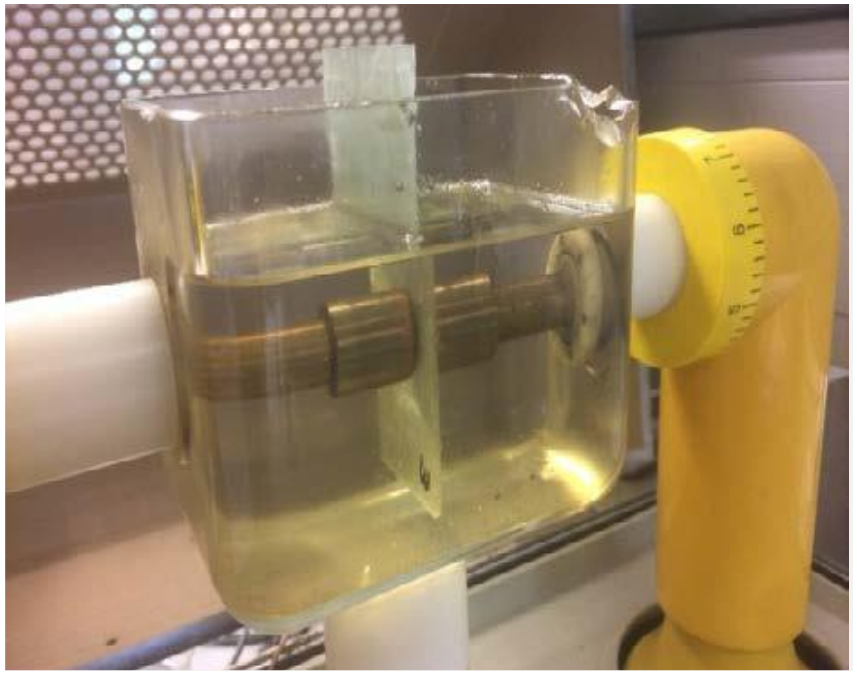
Current design

- CSUB
  - Same production method for tubes (continuous filament winding)
  - 4 legs internally guyed
  - Tubes of glass fibre and polyester ø380 t=5.2 mm
  - Sandwich cross-arm (hand lay-up)
  - Glued connections

  - 28 meter height
  - Weight approx. 4700 kg (without insulator strings)
  - Price…

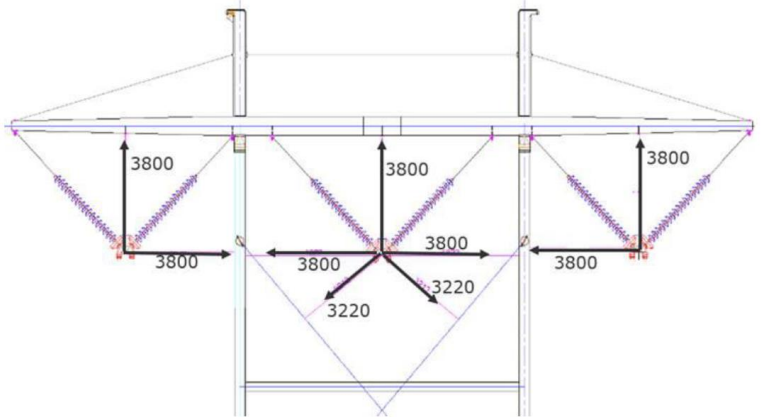
Material testing

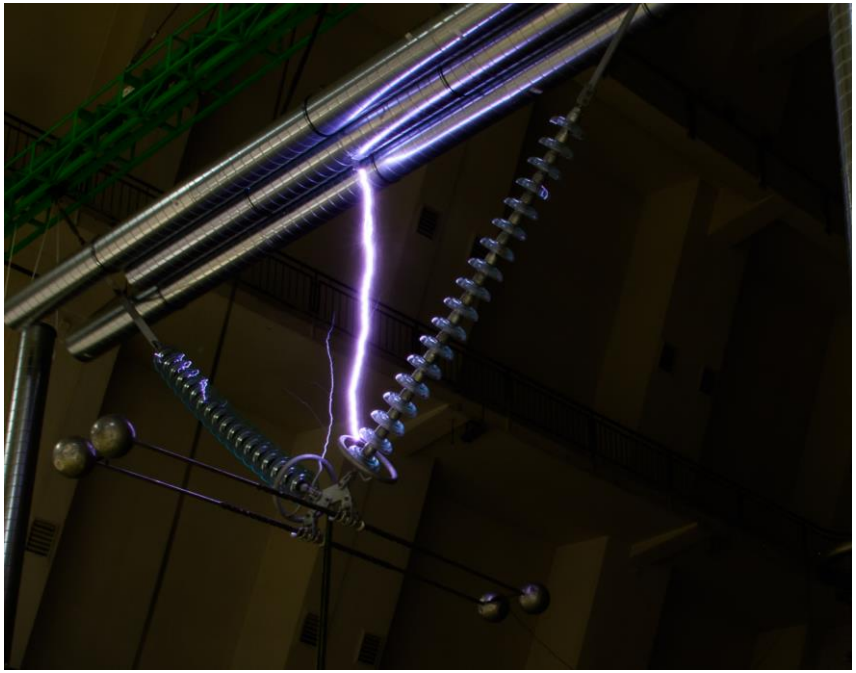
- Performed by DNV-GL Arnhem
  - Thermal linear expansion
  - Water ingress
  - Breakdown voltage
  - Dielectric test
  - Aging test
  - Tracking and erosion test
  - Fire resistance test
- No pass or fail test
  - Important information about the material
  - Semi conductive, grounding important



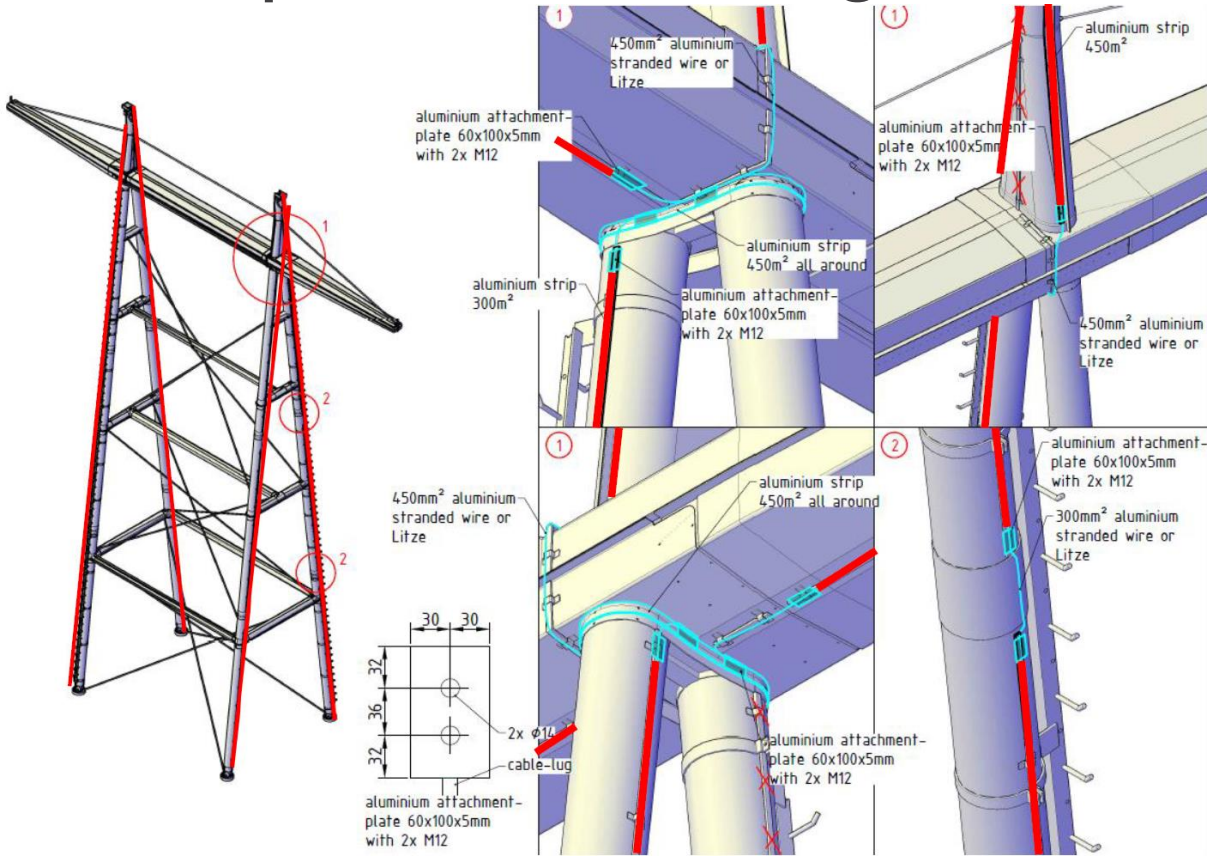
Electrical distances test

- Full scale test
- EGU Czech Republic





Electrical aspects - earthing



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Current status

- Tender for optimization and production of prototype
- Contacted national trade organizations for composite
- Arranged meetings at JEC
- Waiting for offer

Schedule

- April: Tendering process
- Mai – Oct: Design phase
- Nov 2019 – Feb 2020: Production phase
- Mar – Apr: Mechanical and electrical testing

Can we build 420kV towers in composite?

- Yes ☺, but:
  - Cross-arm / joints (glued/bolted)
  - Fire resistance
  - Electrical challenges
  - Light tower
    - Installation time
    - Price

Thank you for your attention!

AWM Installation Robot

Statnett R&D Conference, Livia Dickie

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Oslo, 02.04.19

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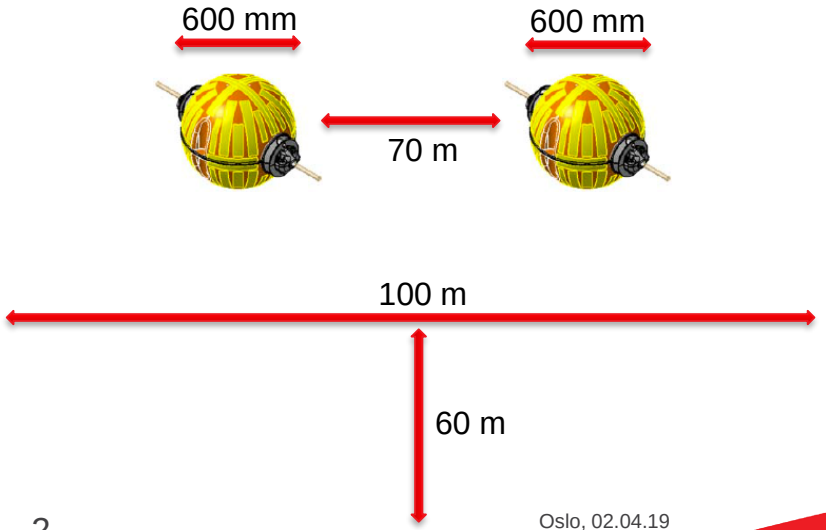
Why?

- Updated regulations
- Operation & maintenance department request:
  - Robot
  - Hangs under helicopter
  - Robust and reliable
  - No more complicated than necessary

Luftfartstilsynet
CIVIL AVIATION AUTHORITY - NORWAY



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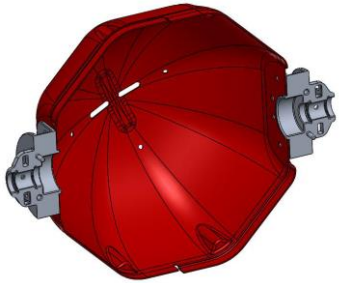
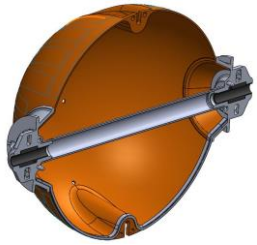
How?

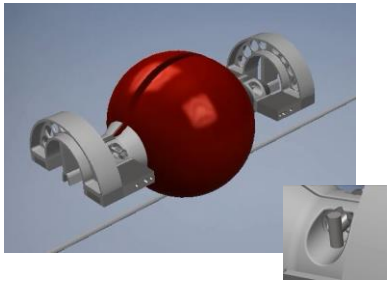
- New lighter AWMs
- AWM clamp design
- R&D project
- EU Best Paths project
- Robot design and supply



Mosdorfer



Dalekovod



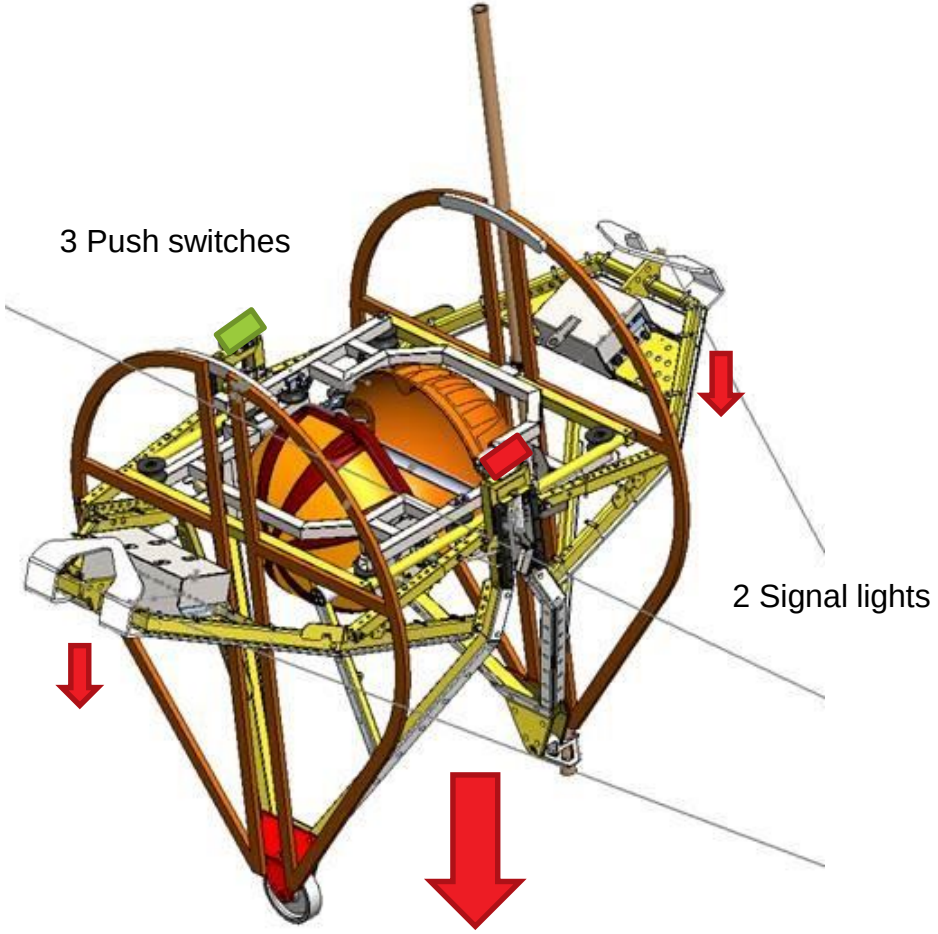
Boris Adum
Statnett

INNOVA

Best Paths

What?

- No control cable
- Installation is automated
- 1 min

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When?

- 2015:
  - Specification & KPIs
- 2016:
  - R&D project started
  - Prototype robot designed, built and tested
  - Prototype AWMs
- 2017:
  - 3 robots built
  - Robot compatible AWMs supplied
  - 58 AWMs installed

GPS

2018 – Ready!

Who???

- Own?
- Use?
- Statnett personnel?
- A selected contractor?
- All contractors?
- Contractor: Product versus Method

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KPI 1. HSE

"Reduced amount of work at height"

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KPI 2. Faster

"Better than 1 day for 1 span (6-10 AWMs)"

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KPI 3. Cost

"At least 20% less"

- 2018: 282 AWMs installed with robot
- Lowest average price "per AWM"
- Risk versus Reward

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More robots?

- De-installation robot?
- Spacer robot?
- What else could the AWM robot install?

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Can robots help improve safety?

Is digital substation a way towards next transition?

R &D Conference

Rannveig Løken and Nargis Hurzuk

Oslo, 2 April 2019

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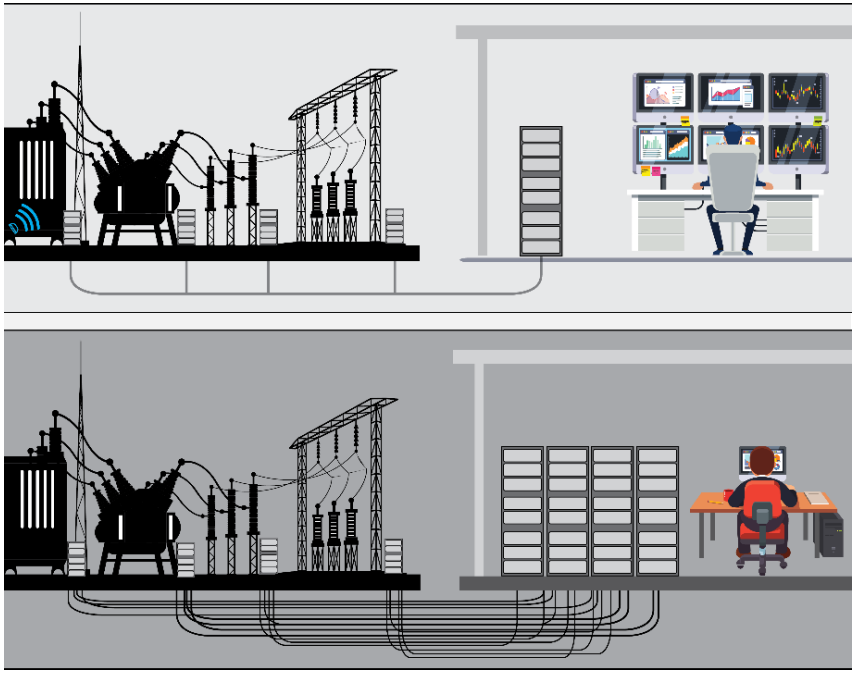
What is digital substation?

- IEC 61850
- Station bus
- Process bus



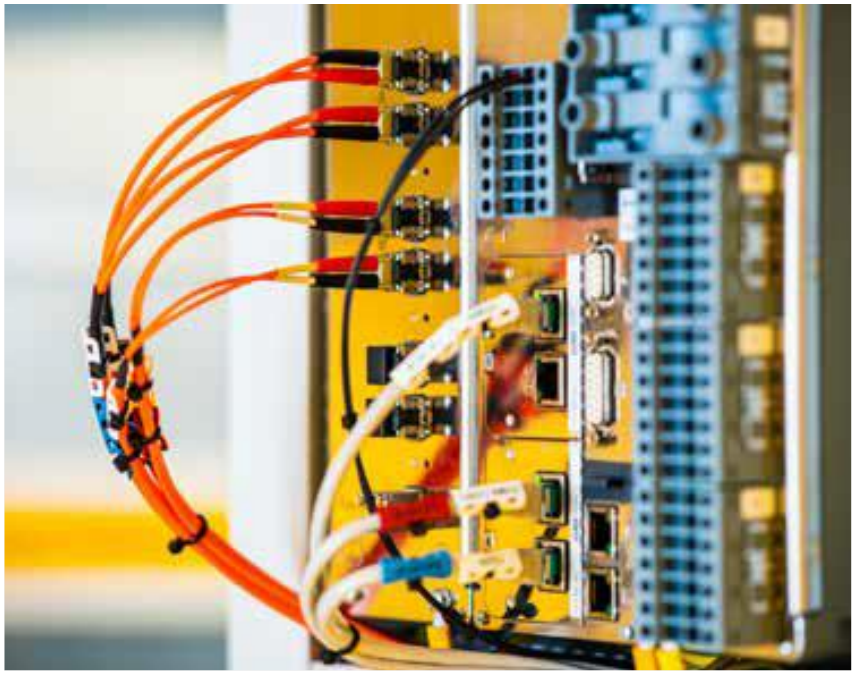
ECoDiS

Is digital substation a way towards next transition?

- Smaller
- Smarter
- Safer

Smaller- reduced footprint

- Substation Layout
- Cable trenches
- Control room
- IED

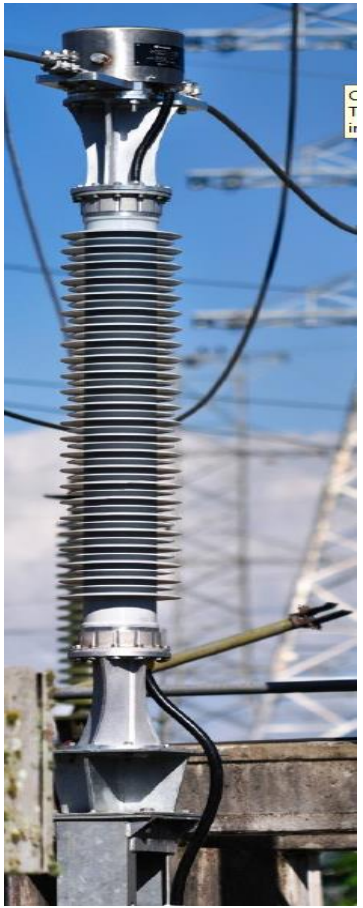


Smarter- datacollection

- Added functionality
- Adaptable to future needs
- Asset management
- Flexibility

Safer- New architecture

- LPIT
- Processbus
- Remote access
- Cyber security



Bay Cabinet- New design

- EMP protection
- Climatic condition
- Optimal Maintenance
- Cyber security

Testing and network analysing

- DANEO
- System verification
- Best Master Clock

Project outcome

- Interoperability
- Cooperation
- Competance
- System design

Is digital substation a way towards next transition?

- Smart
- Secure
- Effective

Can we get rid of our icing problems?

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Oslo, 02.04.19

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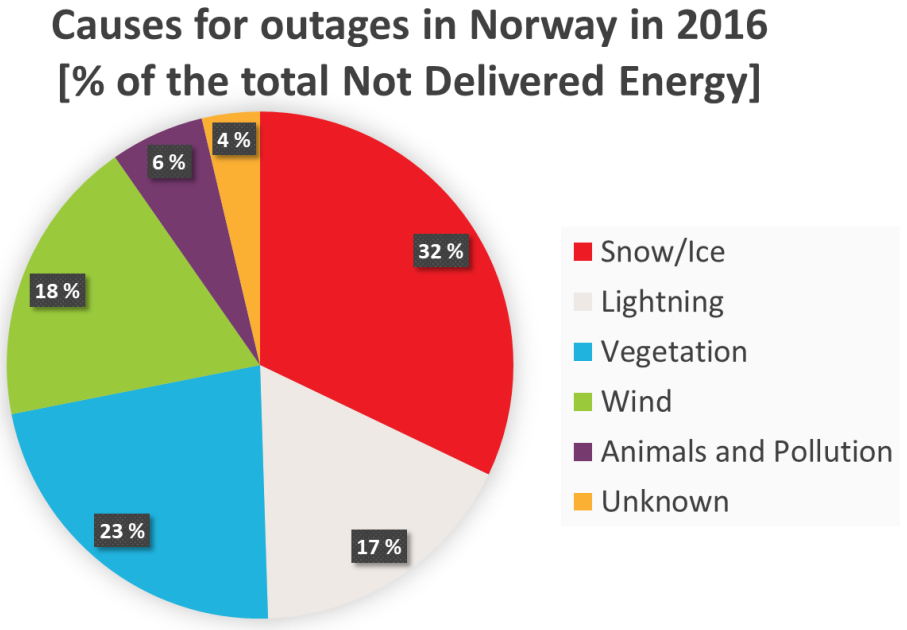
Icing in Norway

- Topography ideal for power line icing
  - High mountains
  - Windy
  - Fjords
- Unofficial world record of 305 kg/m at Lønnahorgi in 1961

Icing in Statnett

- Cause for approx. one collapse per year last decade
  - One event cost over 20 MNOK in NDE only
- Many power lines in exposed areas



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FRonTLines

- 2015-2018
- Focus on modelling of ice-loads
- Established 3 measuring stations still in operation
- Improved ice accretion and shedding model
- NRC funded project

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Icebox

- 2018 – 2021
- Total budget: 36 MNOK

The Research Council of Norway

- 2 PhD

KJELLER VINDTEKNIKK

EFLA CONSULTING ENGINEERS

CICERO Center for International Climate Research

I²G INDEPENDENT INSULATION GROUP

UCAR

UNIVERSITY OF TROMSØ

UiT / THE ARCTIC UNIVERSITY OF NORWAY

LANDSNET

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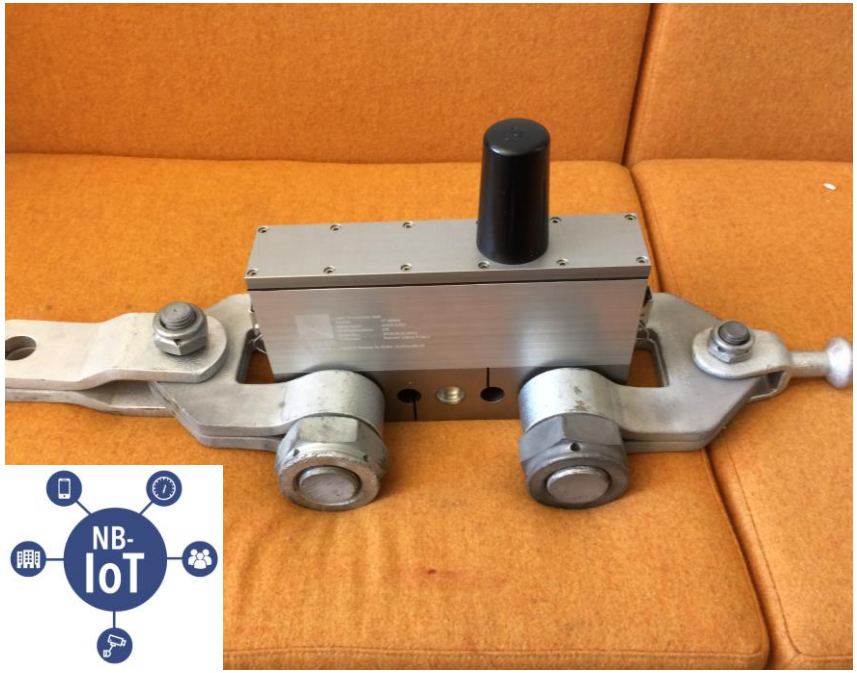
Icebox

- WP1 – Sensors and measuring stations
  - Smart and energy-effective ice-load-sensors
  - Environmentally firendly power supply
    - Batteries
    - Fuel-cell



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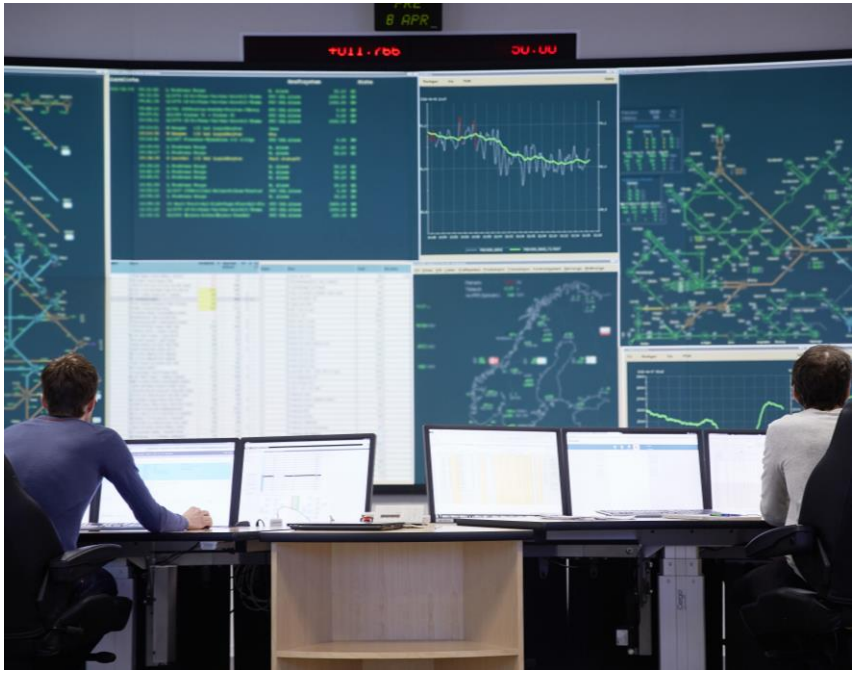
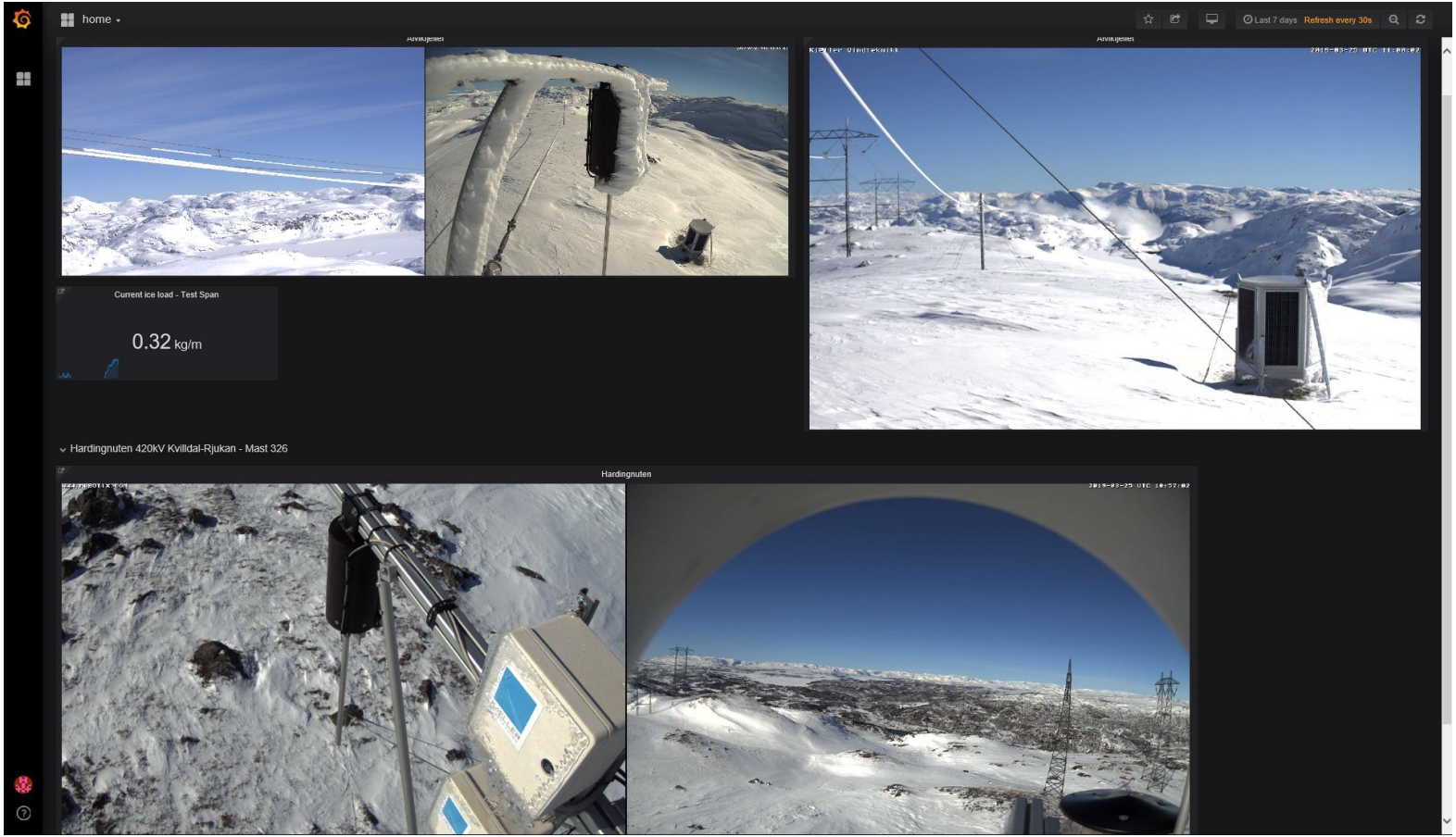
Icebox

- WP2 – Monitoring
  - Live monitoring
    - Current ice load
    - Web cam images
  - Icing forecast
    - 72 hours
    - Weather window for ice removal




home
Last 7 days
Refresh every 30s
Current ice load - Test Span
0.32 kg/m
Hardingnuten 420kV Kvilldal-Rjukan - Mast 326
Hardingnuten

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Icebox

- WP3 – Modeling and climate change
  - Improve models
    - Ice accretion
    - Shedding
  - Models for icing map
    - Climate change

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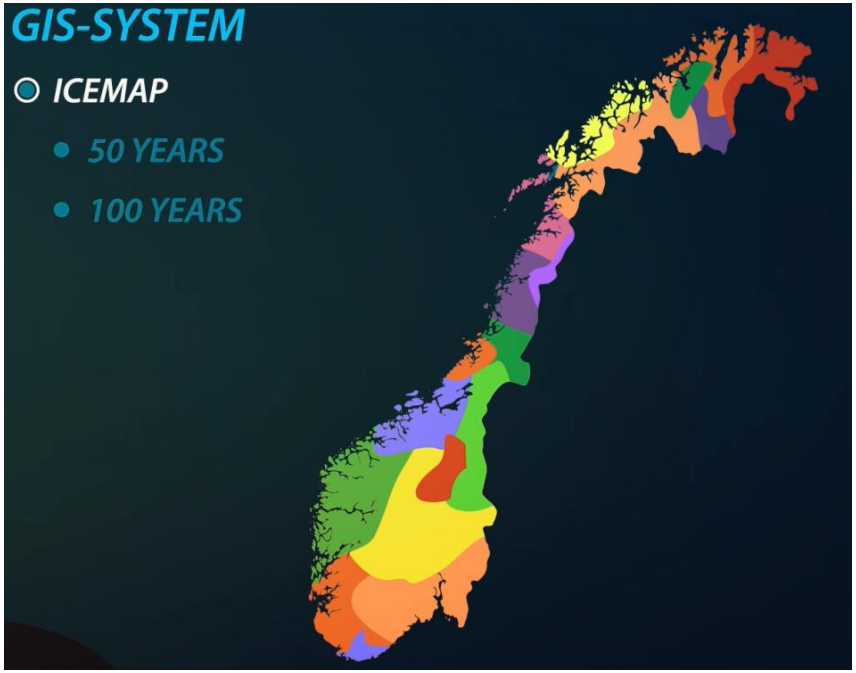
Icebox

- WP4 – Ice map
  - Icing map for all of Norway
    - Climate change
    - Different return periods
    - Orientation of power line
    - GIS
  - Mapping of existing lines



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Icebox

- WP5 – Ice prevention
  - Workshop Oct 2018
  - Theoretical demonstration
    - Coating
    - OPPC
    - Induction spirals
    - Wet snow rings
    - Removal of shield wire
    - Combination of methods

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- WP6 – Ice removal
  - Evaluate and improve existing methods
    - Timber pole
    - Increased current
  - Investigate other methods
    - Drones
    - Robots

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Powerline

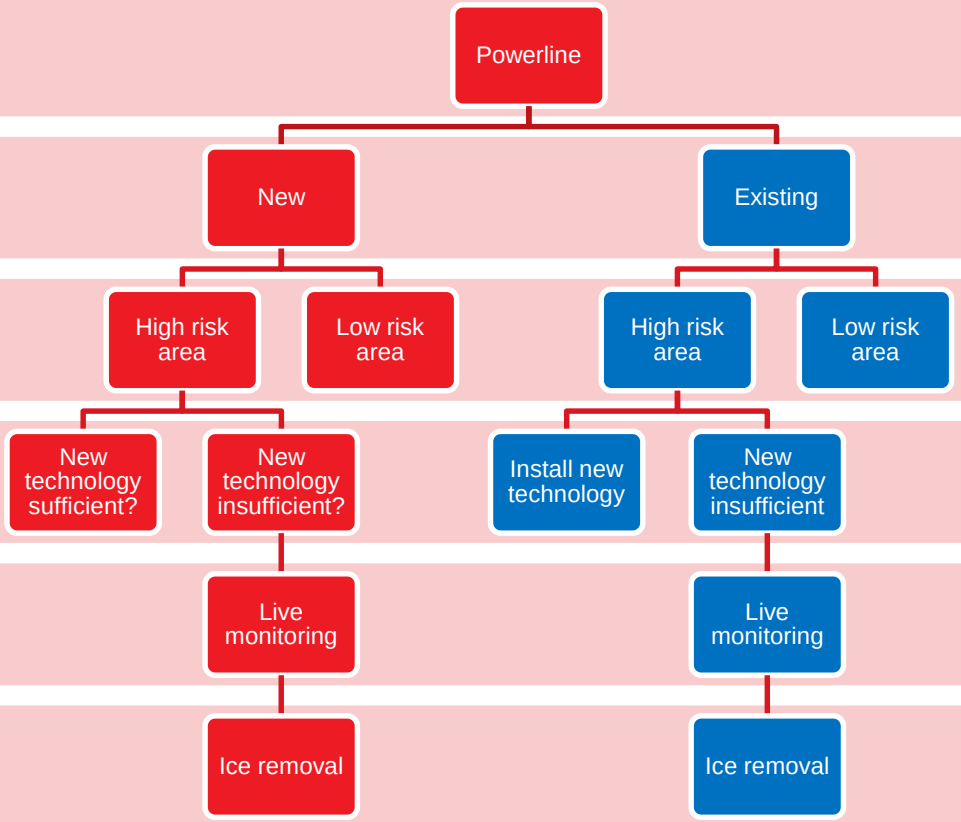
New or existing?

WP 3/4 Icing map

WP 5 Ice prevention

WP 1/2 – Monitoring

WP 6 – Ice removal



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Can we get rid of our icing problems?

- Maybe not ☹, but:
  - We can reduce them significantly ☺ by:
    - Choosing smarter routes
    - Implement ice prevention technologies
    - Monitoring high risk areas
    - Developing ice removal methods for all conditions

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Thank you for your attention☺