Human Factors and control centers for integrated energy hubs

Vidar Hepsø
Professor II Digitalisation NTNU
vidar.hepso@ntnu.no

NTNU: Research and Innovation Program in Digital and Automation Solutions for the Oil and Gas Industry

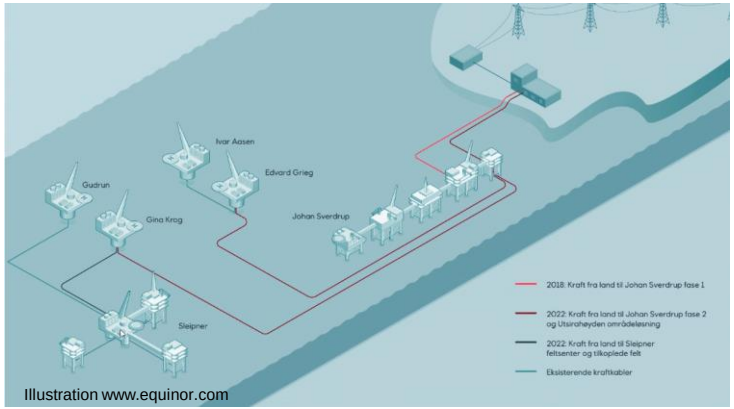


Illustration www.equinor.com

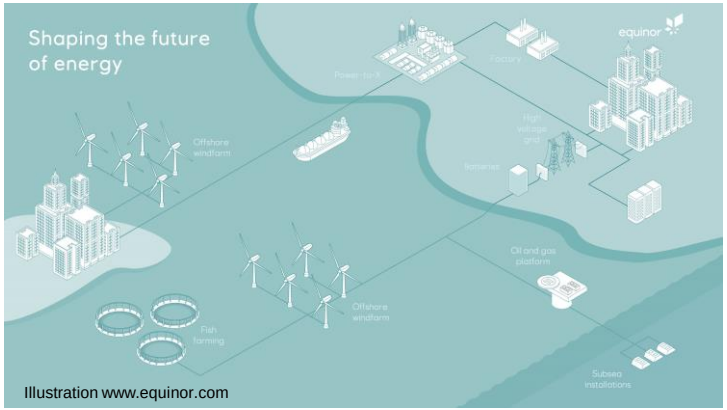


Illustration www.equinor.com

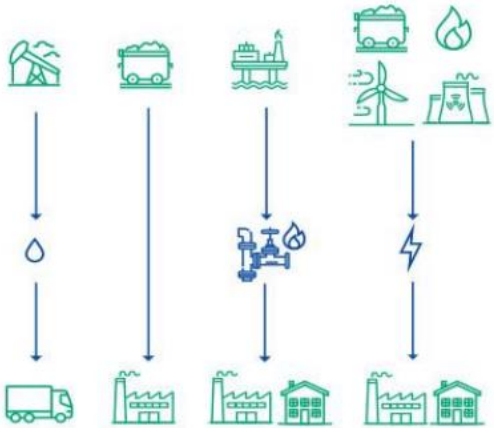
NTNU | Norwegian University of Science and Technology

Todays topic

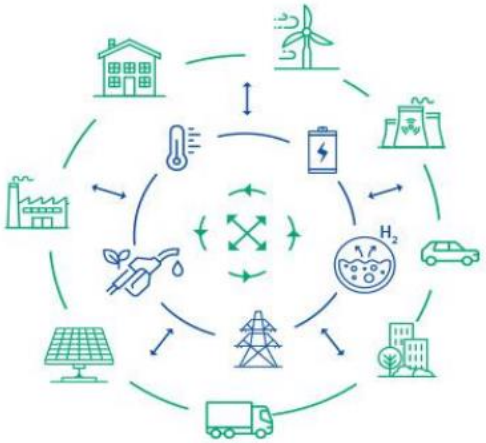
- Human Factor challenges related to control of multi energy systems (electricity production and oil and gas)
- What is happening with offshore wind and electrification?
- Consequences for Human Factors?
  - Control room work as ‘system responsible’
  - New ‘balancing act’
  - New competence mix

System integration: anticipating the energy system of tomorrow

The energy system today :
linear and wasteful flows of energy,
in one direction only



Future EU integrated energy system :
energy flows between users and producers,
reducing wasted resources and money



European Commission

Norway Energy Hub –
the next step for Norway as an energy nation

www.equinor.com/hub

For å lese denne siden på norsk, klikk her

Norway Energy hub is Equinor's industrial plan for Norway's future energy industry, placing Norway at centre stage in accelerating the energy transition. The plan can lead to 350 billion NOK in investments from the private sector. Equinor estimates that we will invest around 100 billion NOK under this plan.

"Equinor aims to be a leading player in the energy transition. This also means that we will shoulder our share of the responsibility for making Norway, as an energy nation, a hub for the rest of Europe. 'Norway energy hub' is an initiative from Equinor, with a clear encouragement to cooperate in combating climate change and ensuring value creation in the energy transition. The opportunity to act is now" says Anders Opedal.

Anders Opedal, CEO

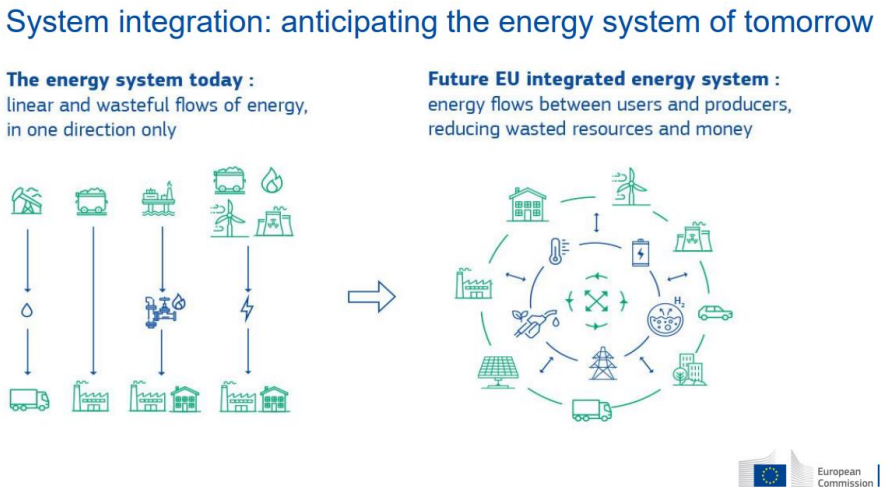
A cooperation to create value and contribute to achieving climate goals:

- Decarbonising oil & gas
- Industrialising offshore wind
- Providing commercial CCS
- Hydrogen on an industrial scale

https://www.equinor.com/en/what-we-do/norway-energy-hub.html
(October 2021)

What is an energy hub and an energy hub control center?

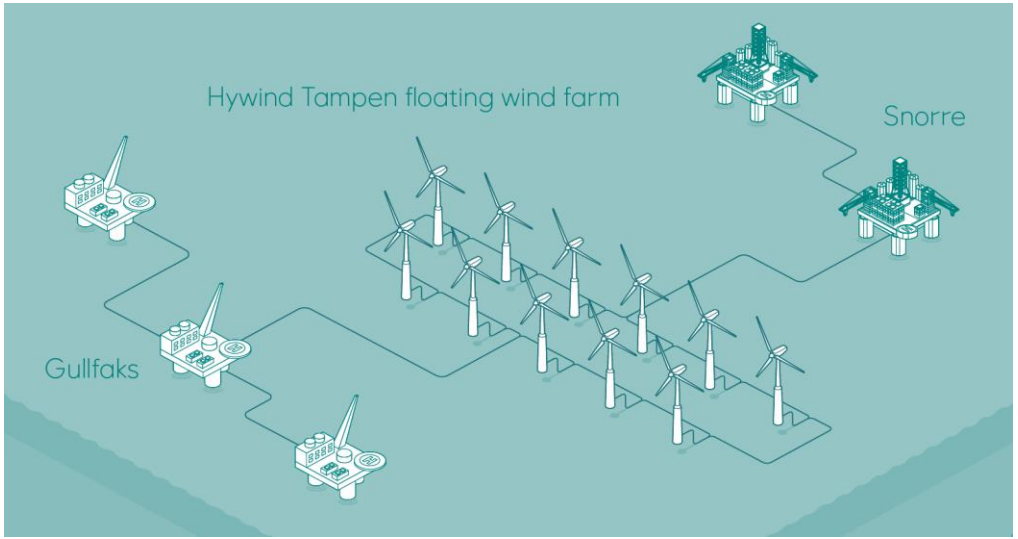
- Energy hub (EH) defined as the place (s) where the production, conversion, storage and consumption of different energy carriers takes place
- A energy hub control centre is a virtual or co-located place where experts in several energy systems performs modeling and optimal scheduling and control of multi-energy systems (MES).
- There will be different types of energy hubs based on markets and local infrastructure.



Mohammad Mohammadi, Younes Noorollahi, Behnam Mohammadi-ivatloo, Hossein Yousefi, Energy hub: From a model to a concept – A review, Renewable and Sustainable Energy Reviews, Volume 80, 2017, Pages 1512-1527, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2017.07.030.

Example 1: Hywind Tampen (2022)

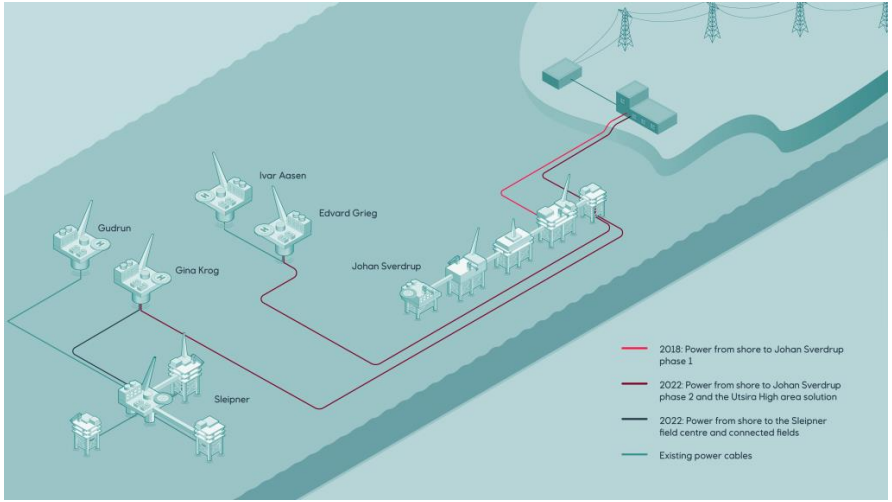
- Integration of energy management and reduced carbon footprint between oil and gas production and renewable energy production
- To be operated from a multifield control room at Sandsli (Valemon)
- Energy load Gullfaks/Snorre integrated with windfarm energy production capacity
- Produce as much wind power as possible from 11 wind turbines to reduce the need for gas turbine power generation at Gullfaks/Snorre
    - Reduction in CO2 and NOx costs



https://www.equinor.com/en/what-we-do/hywind-tampen.html

Example 2: Utsira High offshore electricity grid (2022->)

- Utsira High offshore power grid. Equinor (Johan Sverdrup) given control of the system responsibility by Statnett and the development and operation of the offshore grid.
- Platforms (power cables and P2 HVDC platform at JS) and control room at LQ JS
- Number of agreements with authorities and grid partners (oil companies)
- Control of the operational model (system responsibility of grid and switching) defined in agreements and in work processes, communication routines and IT systems
- Control of critical infrastructure (system responsibility balance of power)



https://www.equinor.com/en/what-we-do/electrification.html

Simplified overview for some energy hub optimization challenges

- One asset has flexibility for energy management
- Electricity provided by gas turbines or a stable energy source from shore

O&G Asset energy requirements

Snøhvit/ Ormen Lange

Energy supplied by single source either by gas turbines or onshore grid system

- Few restrictions on energy supplies
- One to one contact/separation simple coordination and control

- More than one asset in a region
- Prioritize and predict power consumption

O&G Asset (s) energy requirements

Snorre Gullfaks with Hywind Tampen

Energy supplied partially by wind and partly by gas turbines, no onshore grid

- Restrictions in freedom for asset
- More coordination control challenges across assets
- Must develop mechanism for optimizing energy supply based on some criteria: CO2, NOx

- Several assets depend on energy through the same electricity grid
- Asset must predict their energy usage
- Gas turbines last option if power supply is too low

O&G Asset (s) energy requirements

Johan Sverdrup and Utsira High

Energy supplied by onshore electricity

- Restrictions in freedom for asset
- More coordination and optimization regulated in agreements and IT systems
- Onshore power can be expensive or not available in the amount needed
- Must develop mechanism for optimizing energy supply based on Grid line capacity (i.e 300kv)

- Same as previous

O&G Asset (s) energy requirements

?

Energy supplied by onshore electricity and wind power

- As above but wind energy can be an additional source of energy that will reduce the need for onshore power
- Tight coordination, control and optimization challenges of diverse energy systems (gas turbines, wind power and electricity from shore)

System responsible for a regions offshore power grid

-Emerging control room function

- System responsibility: one independent party is given the responsibility to manage an integrated development and operation of the offshore grid system so that all owners and users act coordinated and contribute to a satisfying quality and reliability of the delivery.
  - Power from shore (PFS) agreements document the governance principles between the authorities and the members of the offshore grid
- The system responsibility goes as far down to manage and control the key principles of the system, including:
  - Circumstances that can influence the ongoing power balance and reliability of the offshore grid.
  - Regulation of frequency and effect, regulation of currents/reactive regulation of effect
  - Propose the start up of turbine generators at local platforms when additional power is needed, or when there is scarcity in supply of energy from shore
- Define transfer limits and effect reserves in the offshore grid system
- Approve revision plans and coordinate towards parallel activities at Statnett
- Approve extensions or modifications in the power grid system where these changes can influence the quality and reliability of the offshore power grid
- System responsible normally acts out its role via owners of the different platforms and those that operates the facilities
- Normal day to day operations and maintenance is in most cases outside the system responsible role

Typical tasks for a system responible for the offshore electricity grid (continued)

- Act as electricity switching responsible for the offshore grid
  - The function that has the authority to decide how the offshore grid can or shall be switched (FSE § 6).
  - See to that operational procedures and switching authority is made clear between the assets in the offshore grid
  - Communicate with switching responsible at each platform

Emerging new functions

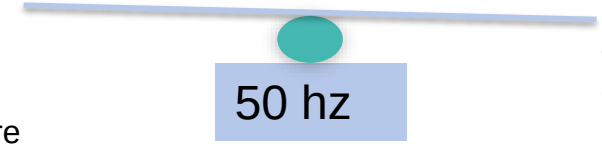
Execute system critical decisions on the offshore power grid like:

- Addressing bottle necks (both permanent and short term) in the offshore power grid
- Decisions on changing operational transfer limits between the assets in the grid
- Initiate/demand start and stop of auxiliary gas turbines on the installations if power use exceeds electric power capacity
- General decisions necessary to maintain the delivery reliability in the offshore grid
- PFS agreements are used as the foundation for the decisions and operating model

The ‘balancing act’

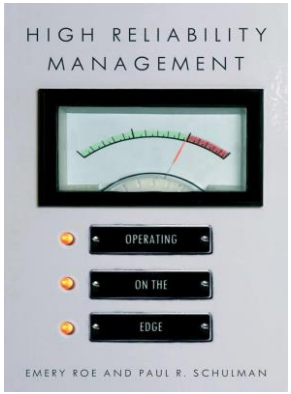
Technical

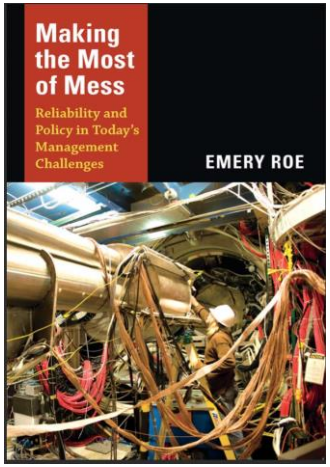
- Power forecasting
- Grid and infrastructure measurements
- HV-switches



Organizational

- Communication/ collaboration
- Work processes (electrical safety)
- System responsibility
- Competence and knowledge of operators
- Governance principles and contracts





Emerging new functions
-A ‘balancing act’

The execution of system responsibility

1. Deliver a continuous balance in the electric offshore grid at any point in time
2. Act neutral and non-discriminating for the others actors in the offshore grid
3. Coordinate and follow up the expectations of all assets that are part of the grid with the intention to deliver a sufficient delivery quality and exploitation of the offshore power grid
4. Collect, verify and distribute information about circumstances in the offshore grid that can have consequences for the general quality of the delivery
5. Have the necessary communication towards Statnett

Movement of operator skills

Johan Sverdrup system operator of the offshore grid

- Process operators controlling oil and gas
- Increased electro competence to operate the electrical critical infrastructure for all the assets in the grid

OFFSHORE WIND: Six remotely operated High Voltage DC transformers Doggerbank (UK)

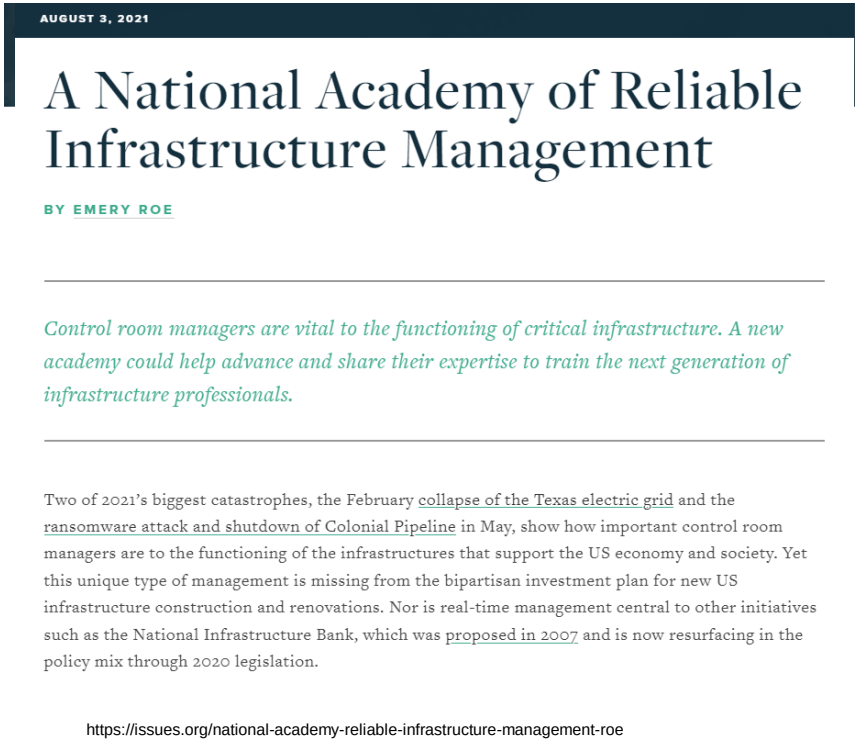
- Electro certified operators in the onshore control room
- Will need process competence to operate the utilities of the HVDC systems

Consequences of control of energy hubs

- From black boxing of simple interfaces to tighter integration interfaces between different energy systems driven by energy transition ambitions
  - More coordination
  - Forecasting and optimization challenges for all parties involved
  - ‘Acts of balancing’ both technically and organizational
- New challenges around developing shared situation awareness across distance
- Need for different mix of technical expertise for control room operators
- More embedded in National Critical infrastructures
- Systems become less bounded, open and more vulnerable

Critical infrastructure competence development

- “Why an academy for infrastructure management? As demonstrated every day, large critical infrastructures must manage in anticipation of their technology, formal designs, and published regulations. The academy’s challenge would be to ensure that the tasks and demands of rapidly changing infrastructure technologies are matched to the people with the skills and expertise to manage them”.



AUGUST 3, 2021

A National Academy of Reliable Infrastructure Management

BY EMERY ROE

Control room managers are vital to the functioning of critical infrastructure. A new academy could help advance and share their expertise to train the next generation of infrastructure professionals.

Two of 2021’s biggest catastrophes, the February collapse of the Texas electric grid and the ransomware attack and shutdown of Colonial Pipeline in May, show how important control room managers are to the functioning of the infrastructures that support the US economy and society. Yet this unique type of management is missing from the bipartisan investment plan for new US infrastructure construction and renovations. Nor is real-time management central to other initiatives such as the National Infrastructure Bank, which was proposed in 2007 and is now resurfacing in the policy mix through 2020 legislation.

https://issues.org/national-academy-reliable-infrastructure-management-roe

The new landscape?

equinor

Statnett

AkerBP

PETROLEUMSTILSYNET

Ørsted

Direktoratet for samfunnssikkerhet og beredskap

dsb

Statkraft

Arbeidstilsynet

NVE

VATTENFALL

RWE

Hydro

Hafslund Nett

TrønderEnergi

Eidsiva Energi

AKER HORIZONS