

Agenda Item No. 4



Ferry Vessel Electrification & Alternative Fuels
Building and Operating Committee Meeting of November 17, 2022



State-owned company and national development bank whose primary purpose is to stimulate entrepreneurship, R&D and pilot projects in Norway.



Norway Delegation



Golden Gate Ferry Objectives

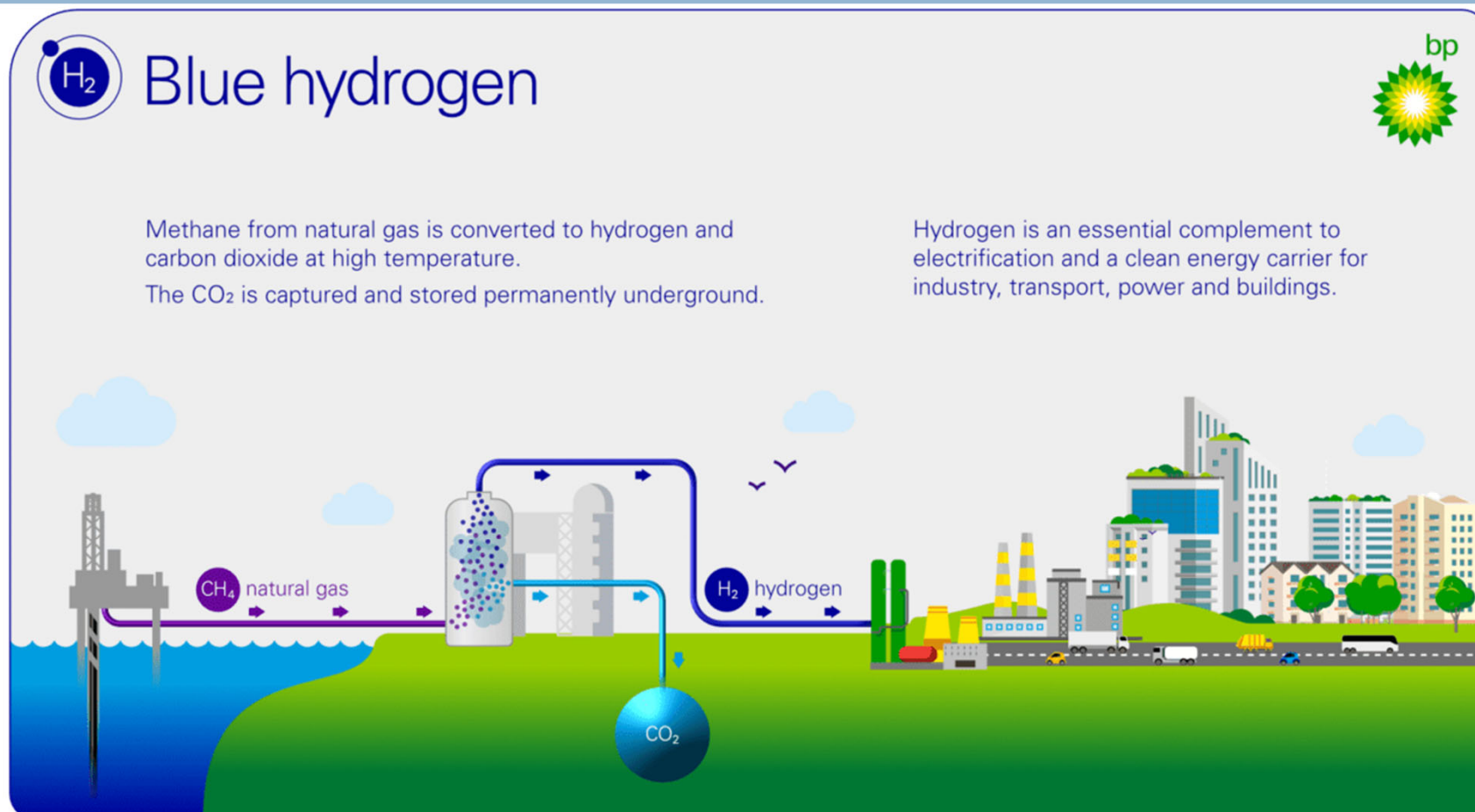
- Primary

- Gain a better understanding of ZEV in real world applications
- Policy improvement & innovation
- Understand current limitations of ZEV & future forecast

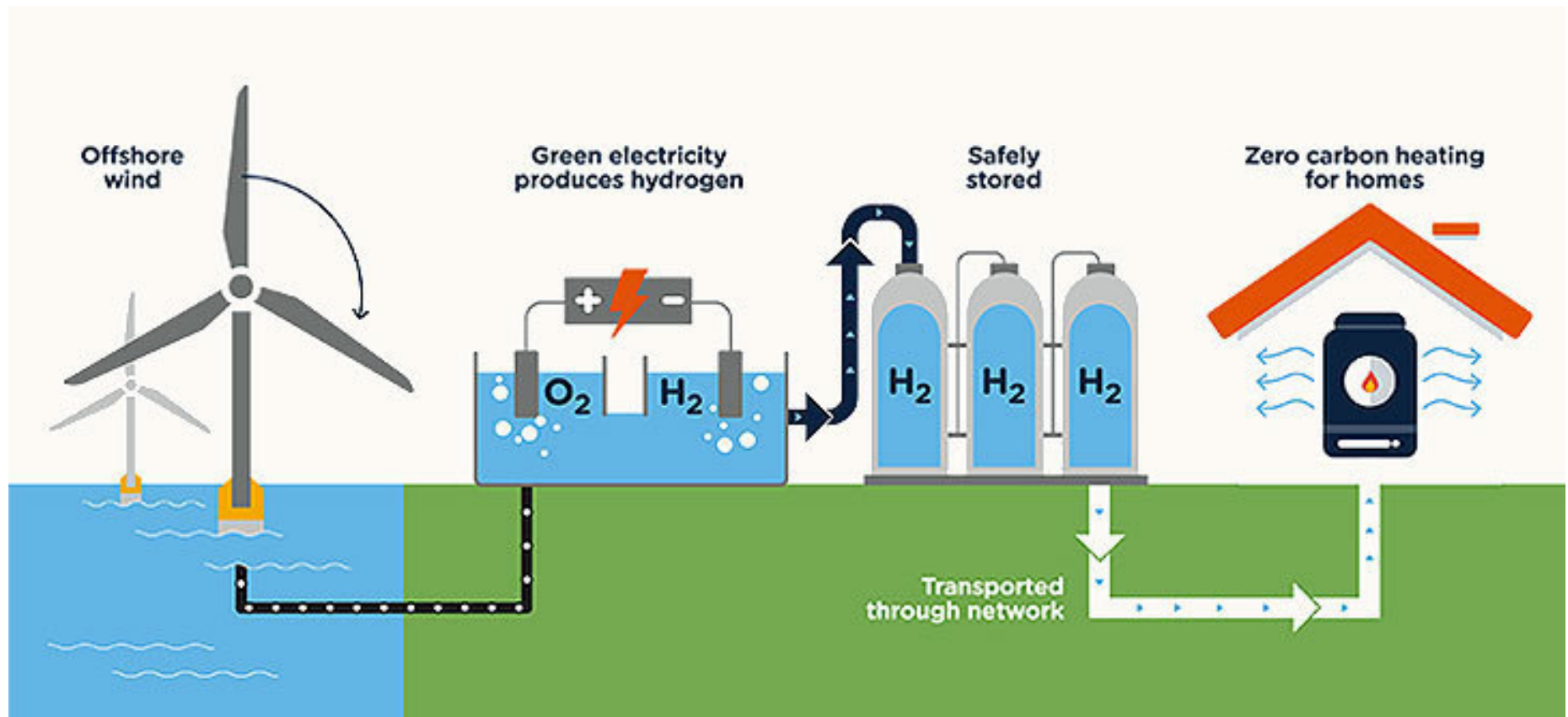
- Secondary

- Explore current technology meeting or exceeding GGF's operating profile
- Value add to District's decarbonization plan

Hydrogen Power Blue vs Green



Hydrogen Power Blue vs Green



Hydra Stavanger – Car & Passenger Ferry (Pilot Project)



Electric ferry with hydrogen fuel cells. Green hydrogen is supplied via truck from Germany. Hydrogen is used in an electrochemical process to generate electricity.

Hydra Battery bank 1 of 2



Electrification & Supporting Infrastructure

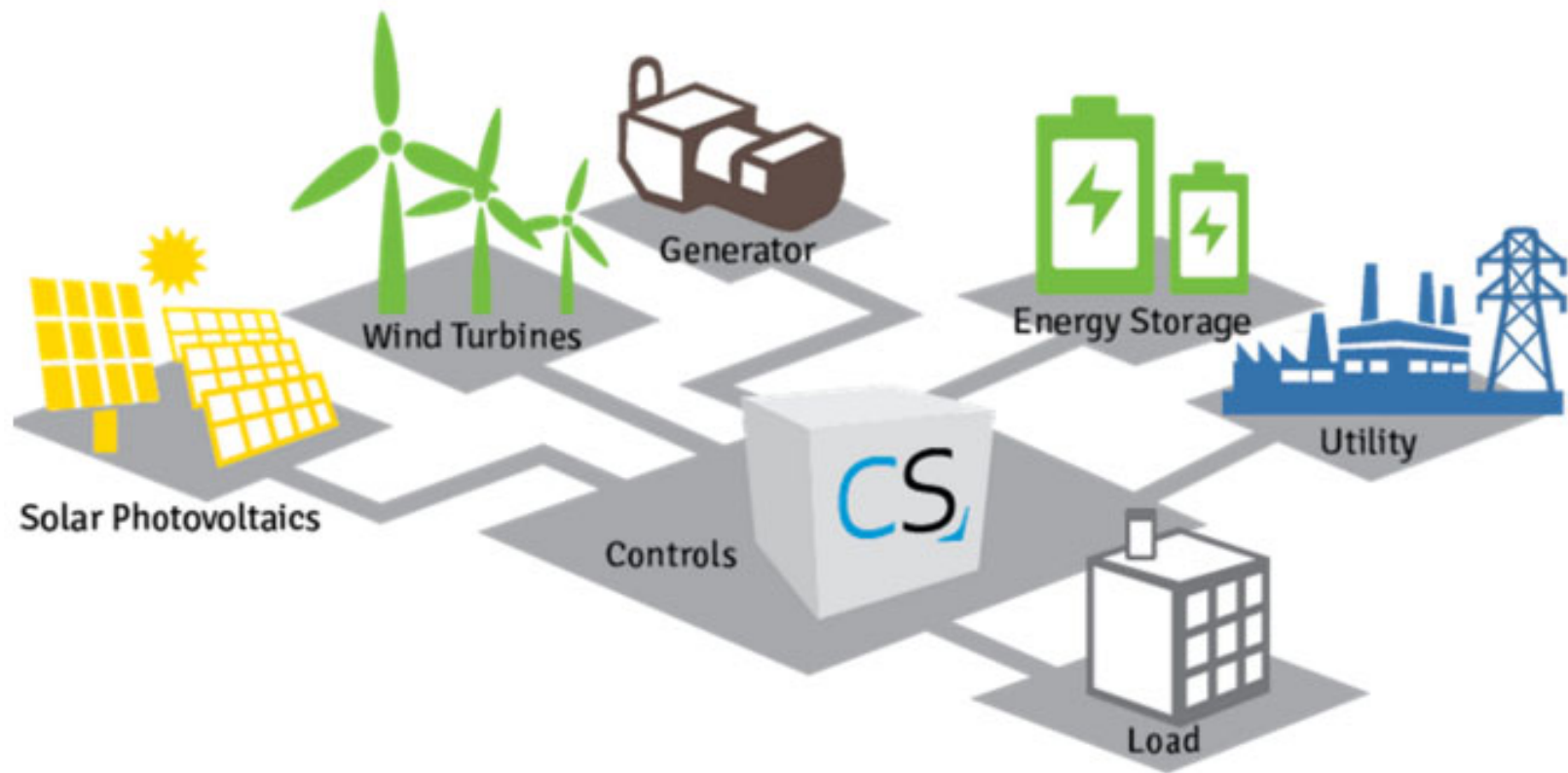


- Rapid charge at 5MW or the equivalent of 10,000 100W light bulbs.
- Provides 350 kWh of power in 6 minutes

Electrical Service Availability

- Power requirements for rapid charge, in many cases is in excess of what the utility provider is able to supply.
- Microgrids are the solution to this problem and serve two key purposes:
 1. Energy storage to support on demand rapid charging.
 2. Programmable for time of use billing structures.

Microgrid Technology



Rygerelektra – Electric “Fast” Ferry



- 23 Knots Max Speed
- 18 Knots Service Speed
- 297 Passengers
- 2.0 MWh Battery
- 46 Mile Range @ 18 Knots
- 58 Mile Range @ 17 Knots

MS Medstraum – Electric “fast” Ferry



- 147 Passengers
- 23 Knot Cruising Speed
- 1.52 MWh Battery
- 15 Mile Range est. @ 23 Knots

Legacy of the Fjords



- 400 Passengers
- 16 Knots Max Speed
- 34 Mile Range
- 20 Minute Recharge Time
- 2.4 MWh Battery

Ferry Division Operating Profile - Catamaran



- 400-500 Passenger
- 33 Knot Service Speed
- 12 Miles One Way Trip
- 5 Minute Turnaround Time

Weight Challenges

Weight & Volume of Energy Storage System for 300 mile Range



- Significant Weight Penalty
- Hydrogen Volume Savings

- Reasons for Optimism?
- Methanol... a Future Fuel?

Energy Store	By Weight (MJ/kg)	By Volume (MJ/L)
Lithium Ion Battery	0.9	2.4
Uncompressed Hydrogen	120	0.01
Hydrogen with 700 bar tank	6.3	0.26
Methanol	23	18
Ethanol	30	23
Diesel	45	37
Gasoline	47	34

Ferry Division Operating Profile - Spaulding



- 700-750 Passenger
- 20 Knot Service Speed
- 12 Mile One Way Trip
- 5 Minute Turnaround Time

Questions...

