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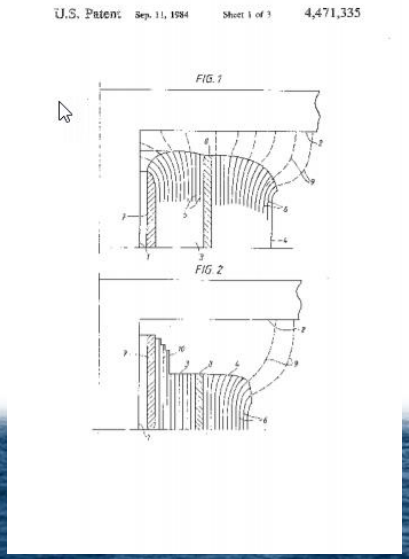
OFFSHORE WIND AND HYDROGEN GAS

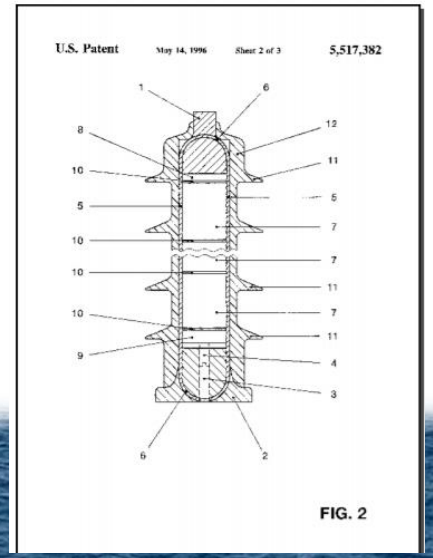
THE ONLY SOLUTION FOR 100 % SUSTAINABLE ENERGY SYSTEM?

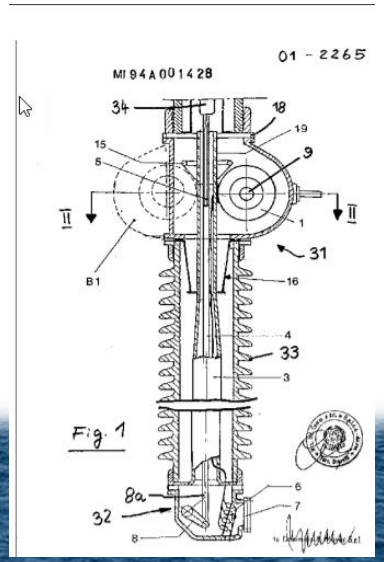
BERTIL MORITZ, INVENTOR

Bertil Moritz	MSc. Eng	Inventor and member of Advisory Board

Industrial inventor with more than 50 patents in his name with hundreds of millions of EUR in sales. MSc Engineering physics KTH.
Senior management positions at ABB.
Currently CEO of HM Power AB and part owner/founder in 8 companies.
HM Power has developed unique "self healing system" for electric distribution network and has strong presence and sales in China.
Bertil Moritz identified the possibility of floating wind power already year 2000 in conjunction with North Sea platform electrical supply and started the creation of FLOW concept in 2008.







CONTENTS

- Vision- the ultimate driver
- Floating offshore design
- Hydrogen from salt water
- Comparisons
- Global solution- least resources

SUSTAINABILITY, THE ULTIMATE DRIVER

If the energy solution requires full sustainability , least amount of resources, then which solution is superior ?

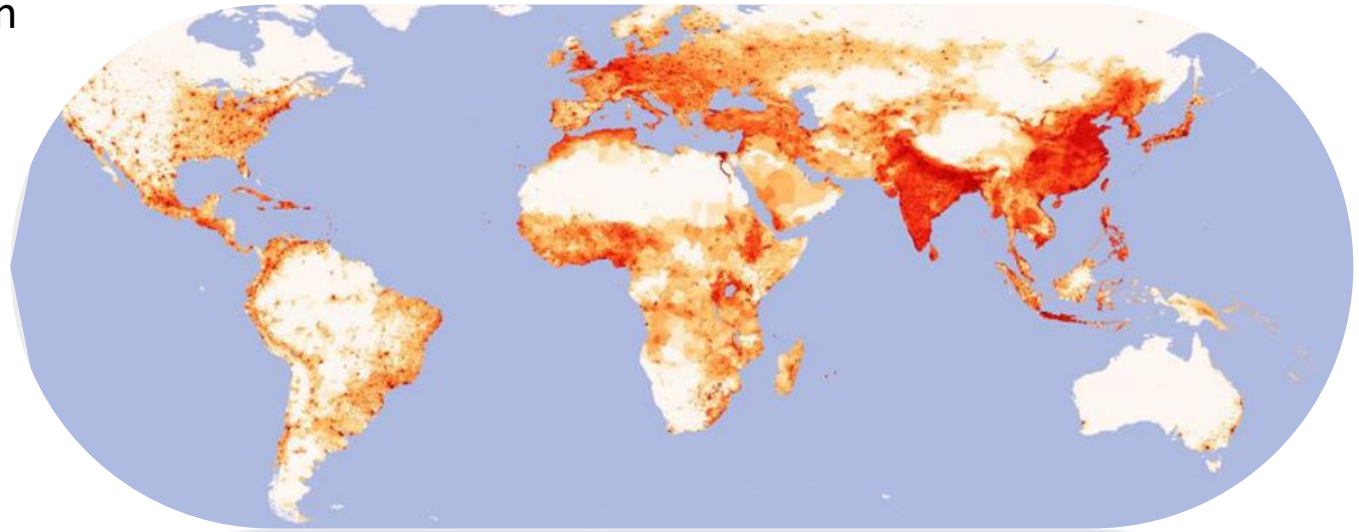
We have investigated current data and alternatives. Comparison of different solutions is made as weight of material , land area and recycability.

GLOBAL DRIVERS

Our World Needs Energy without irreversible overexploitation

Increasing Exploitation

- Pollution of soil
- Pollution of water
- Destruction of forests
- Green house gas emission
- Pollution of air
- Emptying scarce elements
- etc



Growing Population

- Increasing demand for electrical power
- Population stocking to coastal metropolitans

Increasing Congestion

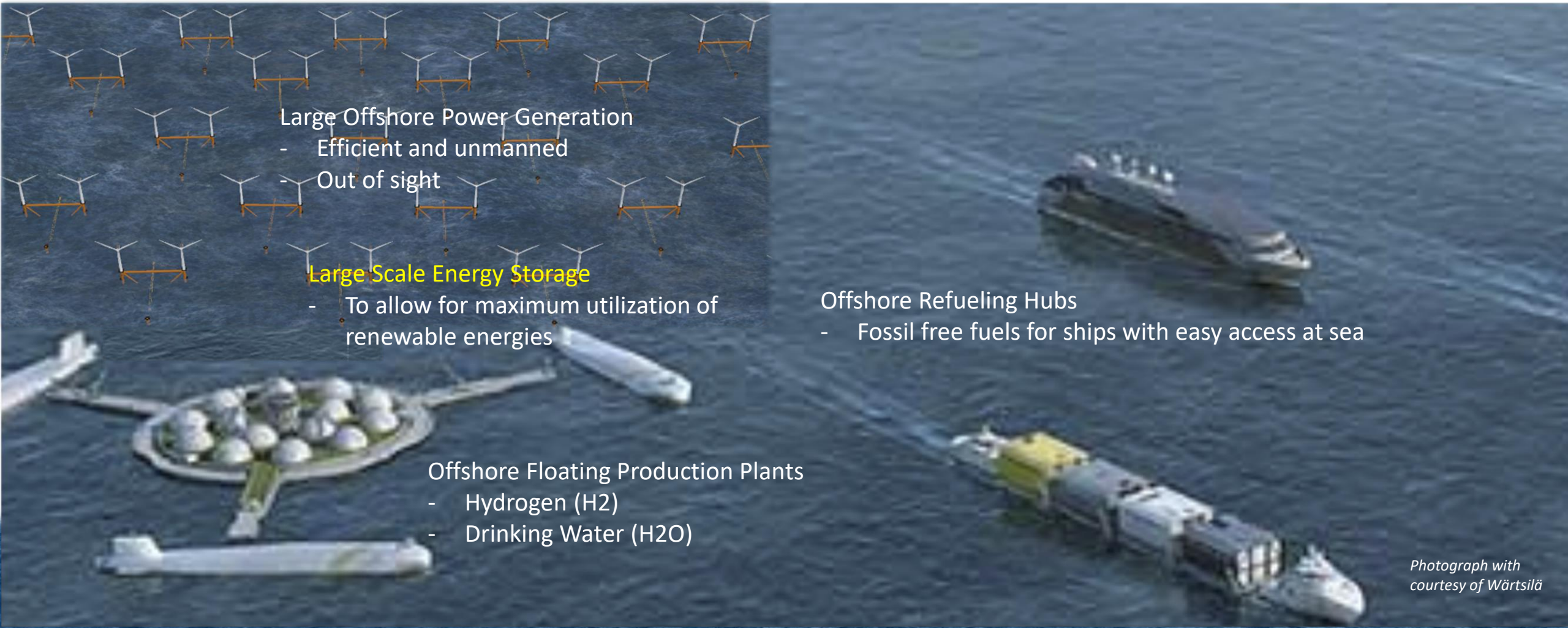
Shortness of:

- Electricity
- Fresh Water
- Accessible Land

VISION

Towards a zero emissions society

Our oceans offer opportunities for large scale production of fossil free energy, in different forms!



Photograph with courtesy of Wärtsilä

WHAT IS HAPPENING TODAY?

US Offshore Wind 2019

Jun 10, 2019 - Jun 11, 2019, Boston, Massachusetts, USA

Gear Up for Commercial Deployment

Offshore wind hydrogen could be subsidy-free within 10 years

May 1, 2019

New offshore wind hy
offshore wind and de
levels, project particip

Europe's leading offsh
production through el
potential and accelera

In March, Denmark's c
hydrogen projects as
projects in the Nether
wind developer by cap
capacity from 5.6 GW

Recent offshore wind
exposing winning dev
to use power from the
produce hydrogen, wh
provide additional rev

the natural requiremer the whole country."

TenneT group plans 100MW wind-to-gas plant in Germany

Element One project would collect power from North Sea wind farms for storage and transport as hydrogen

by **Andrew Lee**

17 October 2018
Updated 17 October 2018

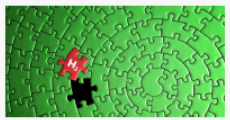
Plans to build Germany's largest power-to-gas plant to convert North Sea wind energy to hydrogen for storage and transport to demand centres have been advanced by a consortium including network operator TenneT.

The Dutch-German TSO, and partners Gasunie and Thyssengas, said the 100MW facility would represent a "comprehensive coupling of the energy, transport and industrial sectors".

The project – called Element One – would collect power from TenneT's substations in Diele and Conneforde, in the northern state of Lower Saxony, for conversion into hydrogen.

That could then be transported by the gas network to users in the industrial and transport sectors.

The three partners hope the plant will begin operating from 2022. No details of cost or investment plans were given.



Hydrogen: the green-energy problem solver

TenneT managing director Lex Hartman said: "We need powerful storage technologies if we want to achieve our ambitious expansion target for renewable energy by 2030. The ability to store large volumes of renewable electricity will reduce the load on the power grid.

"That, in turn, helps us limit the expensive curtailment of wind turbines and make the power supply more reliable."

E.ON unit to test feeding up to 20% of hydrogen in gas grid

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grids at higher leve

Berlin

subsidiary of German
sdorf to raise hydrogen

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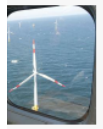

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Germany is
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the energy
are current

Hydrogen: the green-energy problem solver

IN DEPTH | It can be produced with zero emissions, stored indefinitely and be used as a clean fuel for energy storage, transport and heating. But when will H2 be a cost-effective solution? asks Leigh Collins

by **Leigh Collins**

13 September 2017
Updated 15 September 2017

Whisper it softly, but a clean, green solution to the energy industry's most intractable climate conundrums may be in sight — and it is almost as old as time itself.

Many experts believe that the transport industry can never be decarbonised using renewable energy alone; that heat cannot be produced on a massive scale without burning hydrocarbons; and that intermittent wind and solar will never be able to cover the so-called seasonal gap in winter, when there is simply not enough sun or wind to produce the energy needed to meet peak demand, no matter how much is stored in batteries or pumped hydro plants.

If only the planet had an affordable, emissions-free version of a fossil fuel — one that could be stored indefinitely, can generate both electricity and heat (with or without fire), and be able to power trucks, trains, ships and planes.

Well, such a fuel already exists and it can be produced on an industrial scale using little more than renewable energy and water. It also happens to be the most abundant element in the universe.

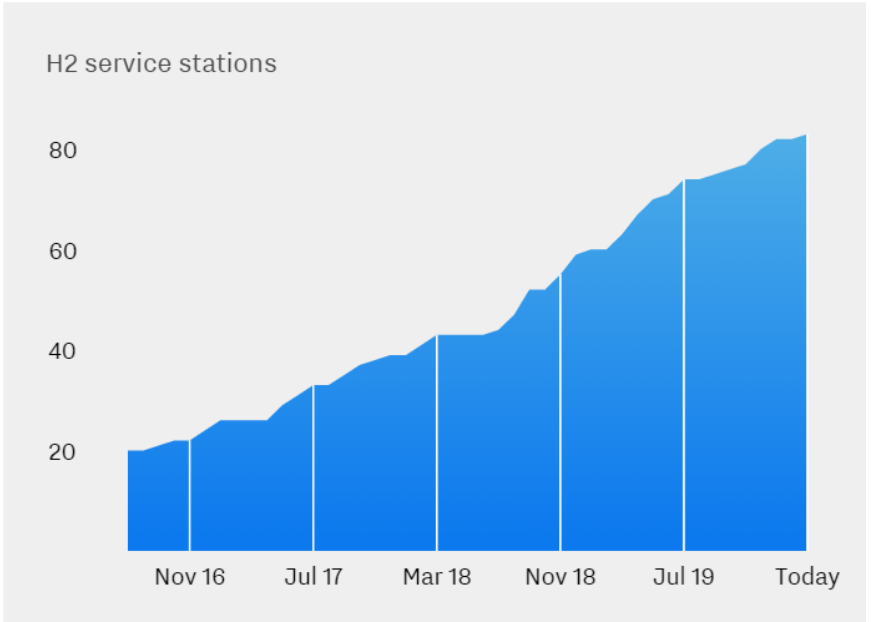
Shell drives forward with its plans for the energy transition

Hydrogen production

Hydrogen cannot be found on Earth in its pure state (H_2). It has to be extracted from naturally occurring molecules — most notably water (H_2O) or natural gas (methane) (CH_4).

H2 service stations for EVFC cars

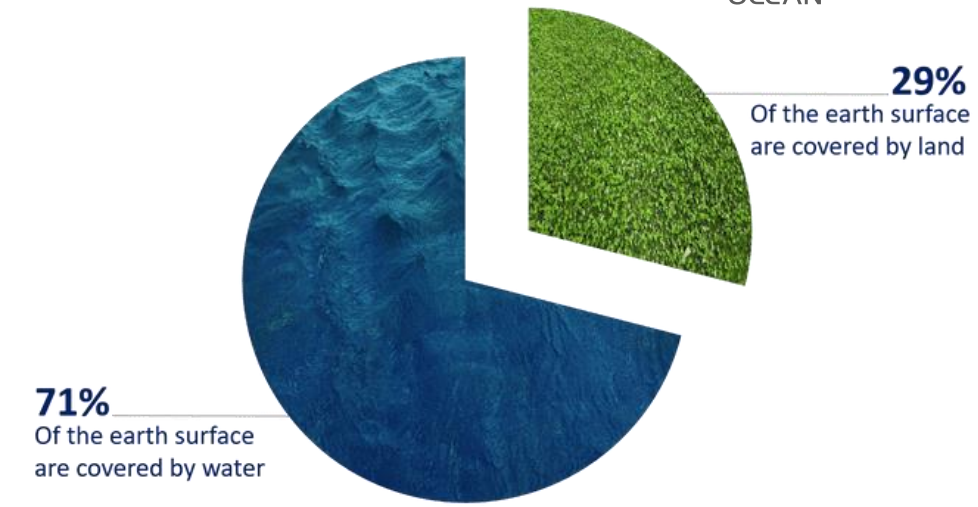
As of today: 83 H2 service stations are open
in Germany

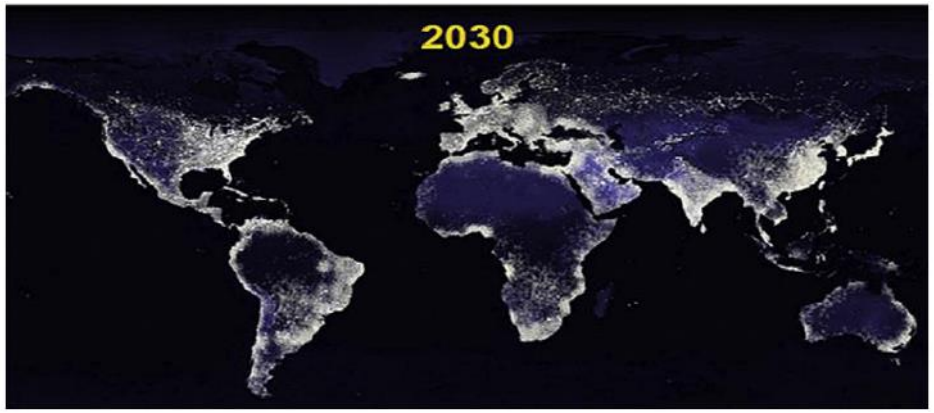


WHY OFFSHORE WIND?

- **Offshore wind power is a sustainable source of electricity**
  - More electricity produced (capacity factors up to ~56 %)
  - Produces no carbon dioxide
  - Takes up no valuable land space
  - Consumes no fresh water for cooling or cleaning

- **Electricity is produced close to consumption**
  - Most power consumed is in coastal areas
  - Good onshore wind locations will be very difficult to find
  - Transporting electricity long distances to the city expensive
  - Most coastal cities have huge untapped offshore wind resources
  - Most coastal cities have industries that benefits from the work that offshore wind provides





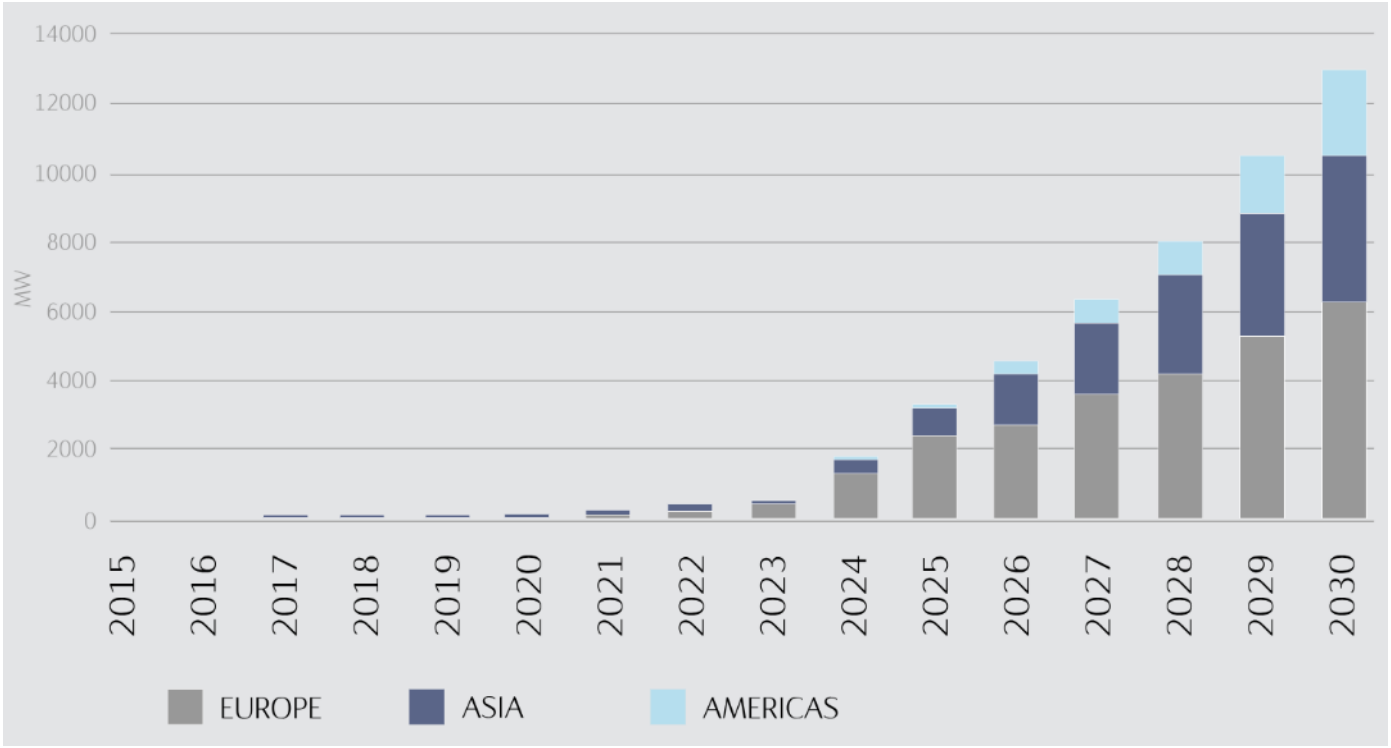
WHY FLOATING WIND?

- **Fixed mounted offshore wind power has limitations**
  - Far too expensive beyond 50 m depths
  - Difficult to standardize

- **Floating solutions open up new vast opportunities**
  - High capacity factor (in par with gas/coal!)
  - Far less constraints, less intrusive
  - More flexibility in installation to optimize economics
  - Can be standardized
  - Not sensitive to water depths, applicable for 1,000 m

- **Vast potential**
  - Most future projects will be in waters with depths more than 60 m

Multi billion dollar market for floating wind anticipated by Norwegian Equinor (f. Statoil)



Source: Carbon Trust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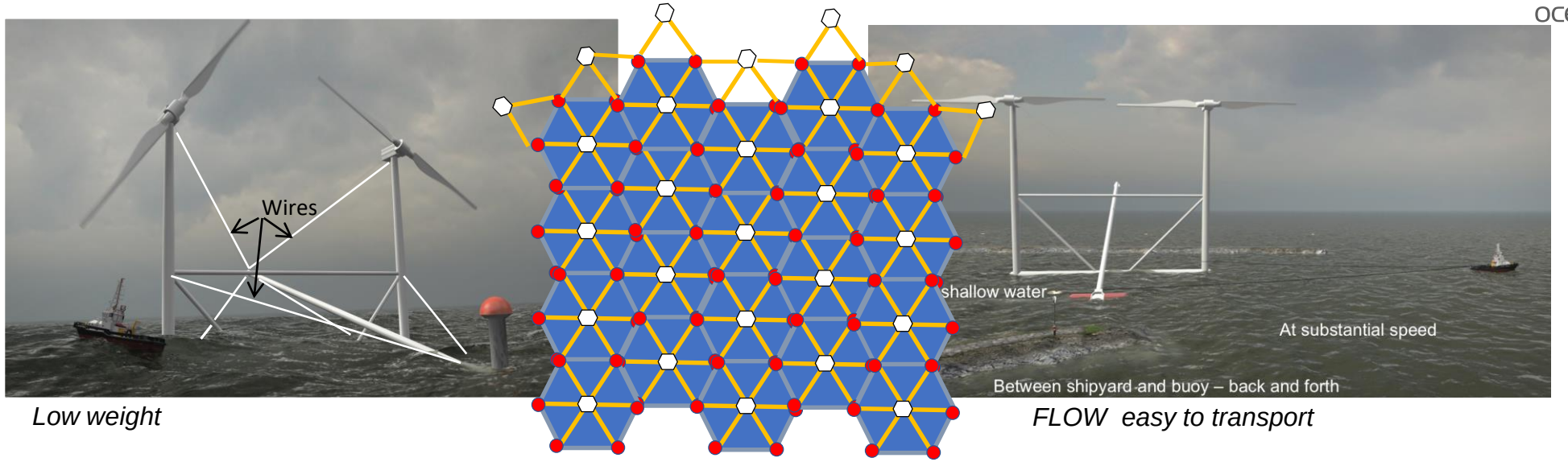
LEAST MATERIAL / MW

FLOW overview

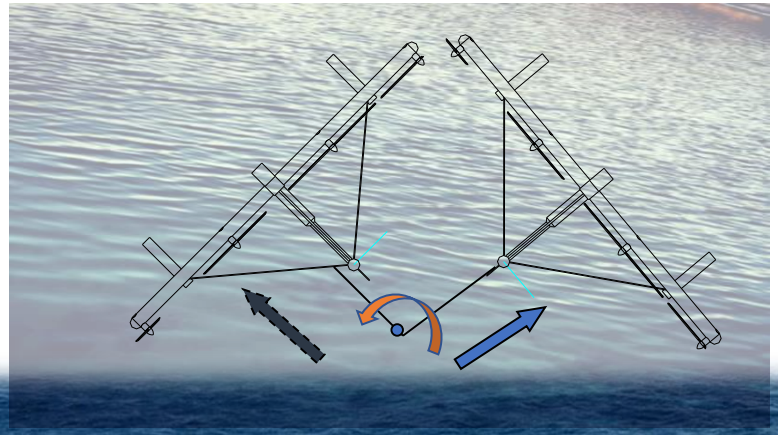
Efficient use of wind farm area



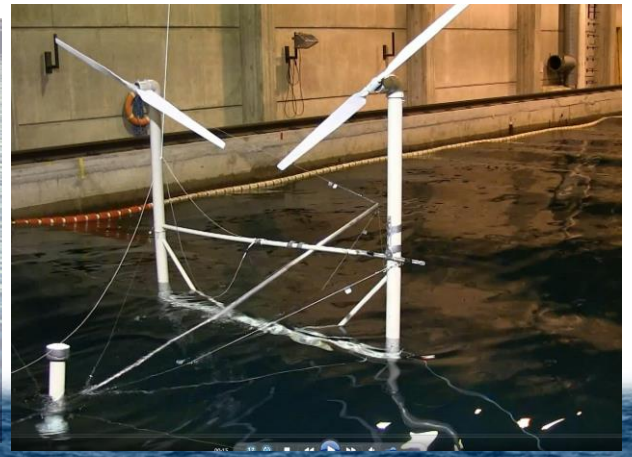
Low weight

FLOW easy to transport

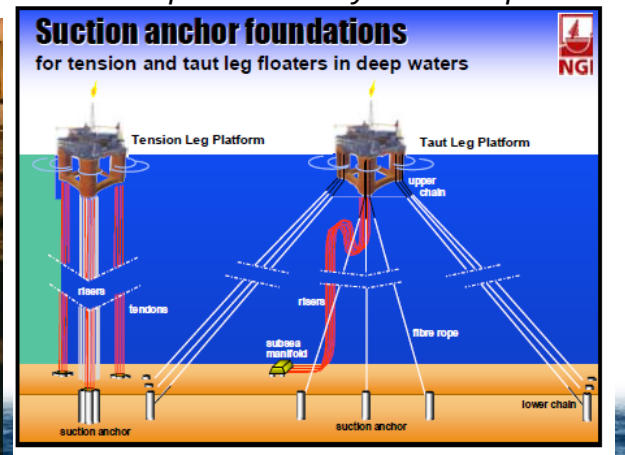
Self adjusting vaning towards wind



Model tested



Well proven sub system components

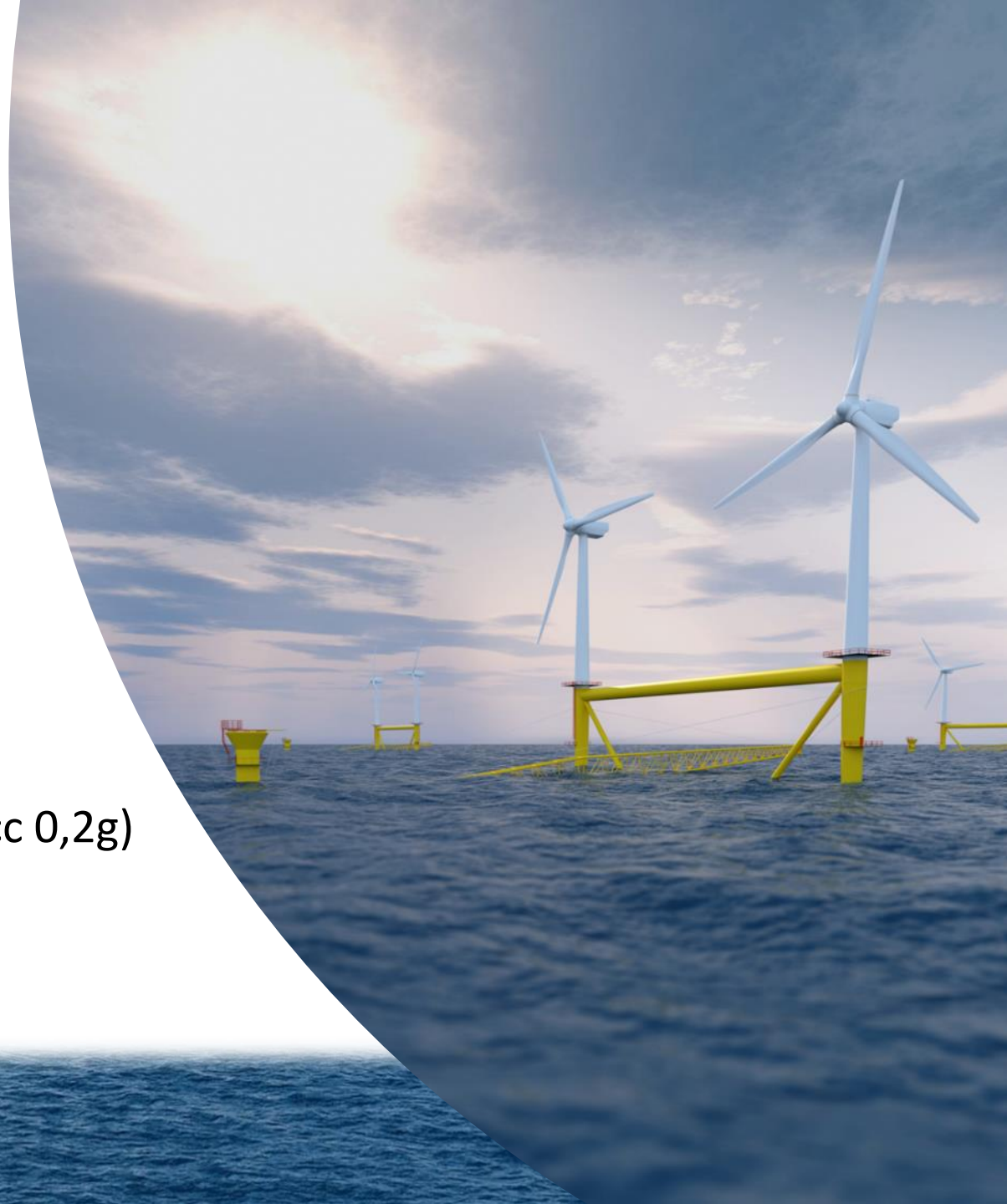


Main problems solved

- Both immunity to waves and stability (contradiction)
- ”No” bending moments
- Smaller turbines
- Low weight and cost of mooring system
- Cable suspension
- Jaw elimination
- Plug & play
- Towing
- Swivel electric connection

Key Features

- Multiple turbines (lower cost /MW)
- Unique light structure (wires)
- Platform yaw by vaning
- Suction pile mooring system for deep water
- Polyester ropes for mooring
- Fully fabricated at shipyard
- Easy connect/disconnect to buoy
- BOTH stable AND low eigenfrequencies (Max acc 0,2g)
- No digging of cables



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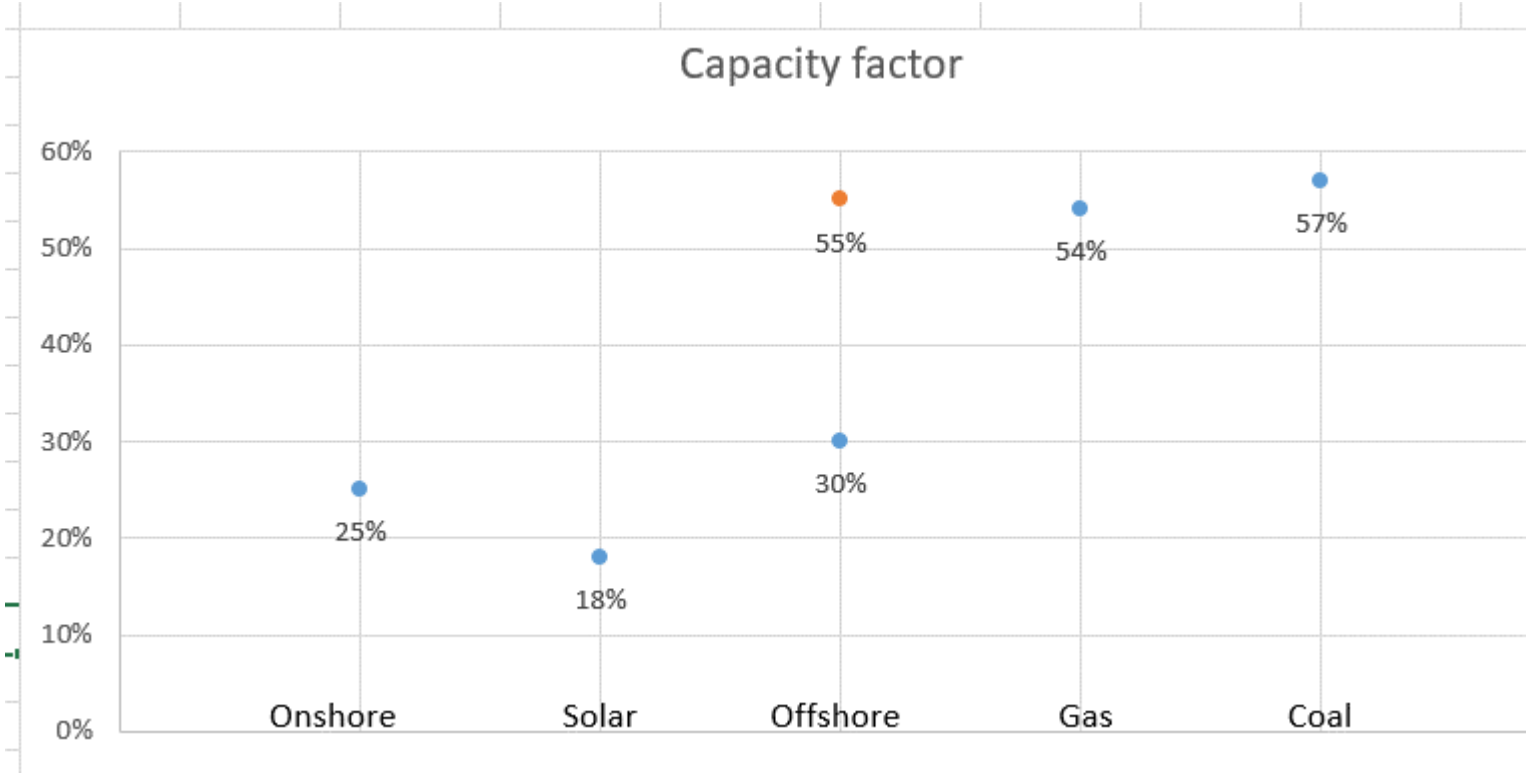
- About 50 % less costs
- Up to 70 % less weight
- Withstand all extremes
- Plug & Play
- Smaller turbines has less weight per MW, 2 better than one

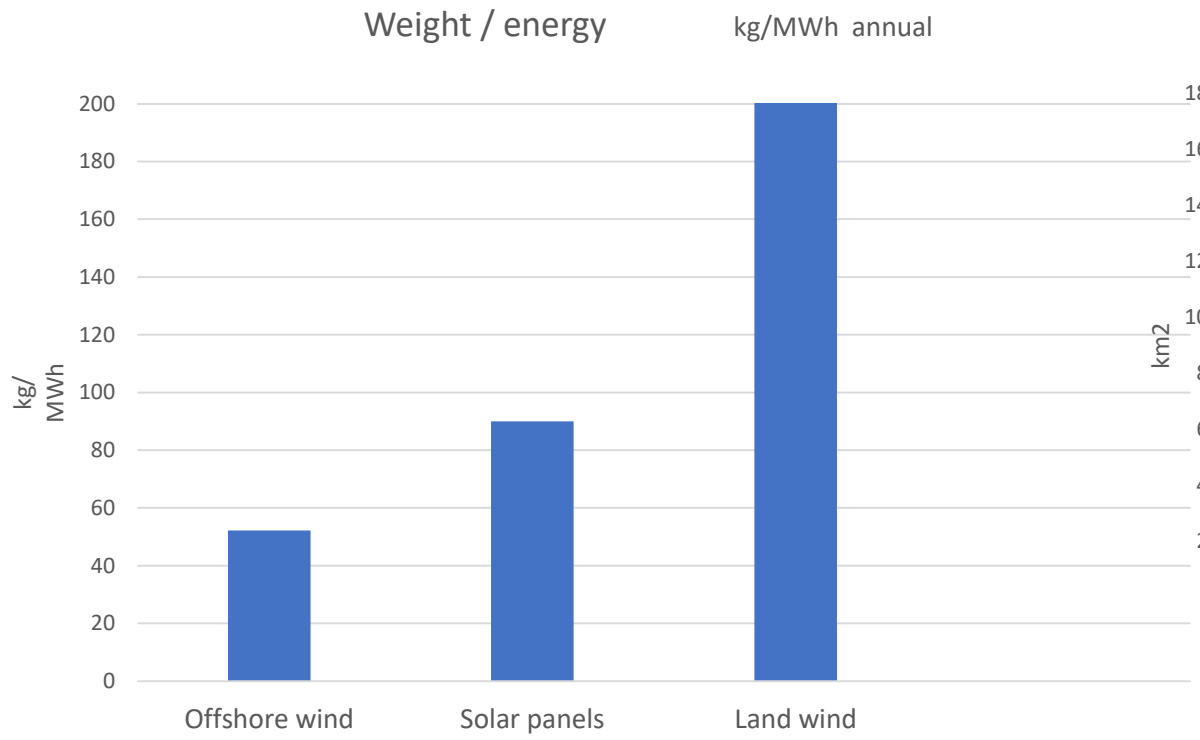
”Wind is seldom blowing..”

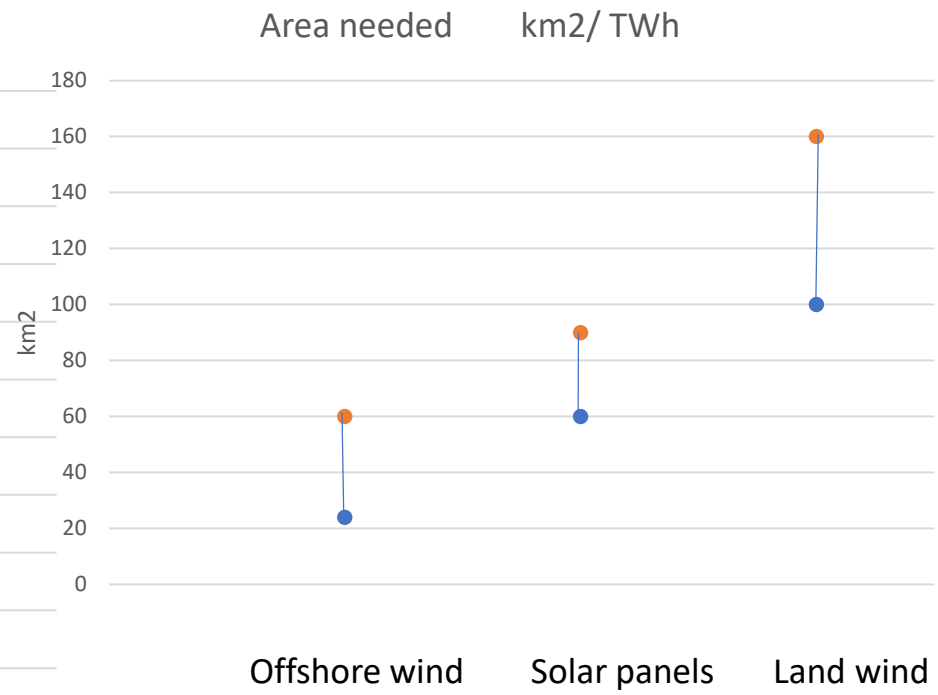


Offshore wind on North Sea has **same level of capacity factor** as world average gas/coal plants !!

Comparison other renewables

Weight of power plant



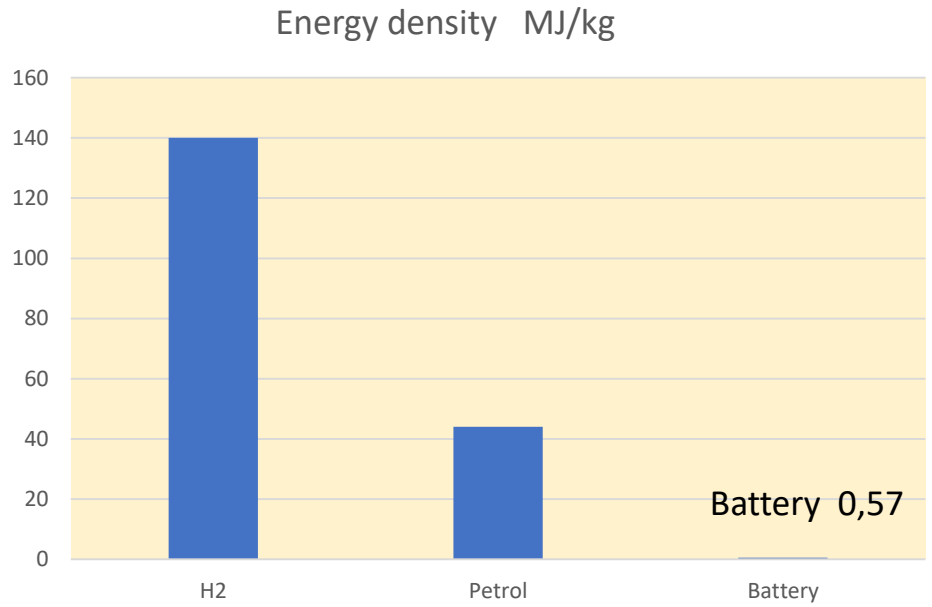


Jules Verne predicted 1874 :

“Hydrogen and oxygen, used singly or together, would eventually furnish mankind with an inexhaustible source of heat and light.”

Far out - Hydrogen from salt water

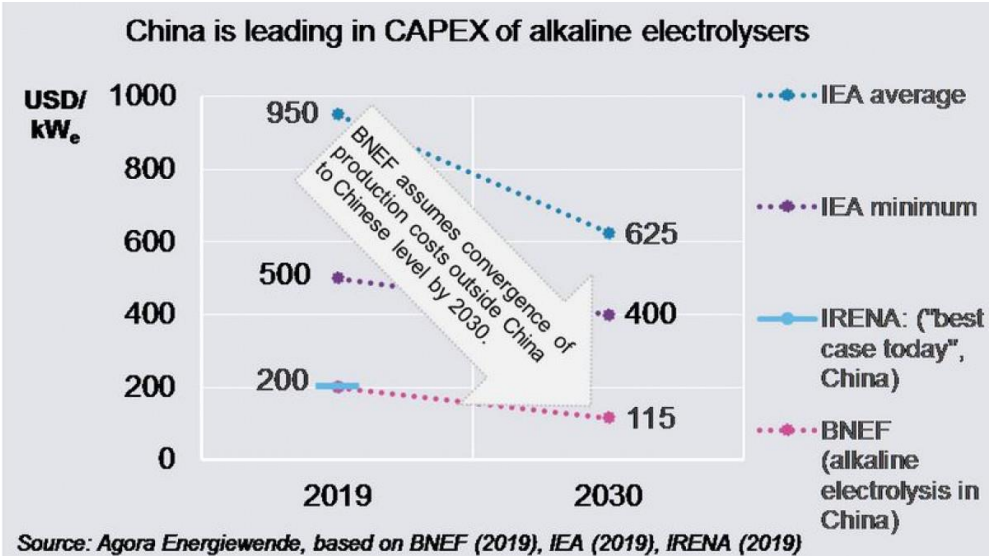
- No need for land cable
- Solves the **storage** problem
- Fuel for transport and heat
- Energy density superior



- The National Renewable Energy Laboratory estimated that 1 kg of hydrogen (roughly equivalent to 3 kg, or 4 L, of petroleum in energy terms) could be produced by wind powered electrolysis for between $5.55 in the near term and $2.27 in the long term.[37] .... 5 SEK/lit petrol **Already history, see next**

Research firm BloombergNEF (BNEF) :

The report's findings suggest that renewable hydrogen could be produced for $0.8 to $1.6/kg in most parts of the world before 2050. This is equivalent to gas priced at $6-12/MMBtu, making it competitive with current natural gas prices in Brazil, China, India, Germany and Scandinavia on an energy-equivalent basis. When including the cost of storage and pipeline infrastructure, the delivered cost of renewable hydrogen in China, India and Western Europe could fall to around $2/kg ($15/MMBtu) in 2030 and **$1/kg** ($7.4/MMBtu) in 2050. (1$/kg H2 = 25 öre/kWh)



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Trucks and train transport hydrogen to different end-users. Surplus can be transported to long-term storage

Heat

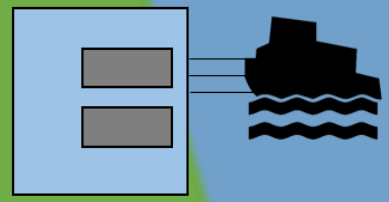
Electricity

Transport

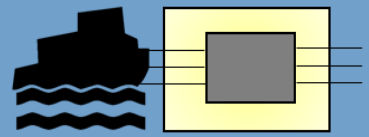
Industry

Boats collects the hydrogen gas and transports to shore to a sub-station. The boats are fuelled and driven with the hydrogen gas

Floating power plants can be installed where the wind resources are optimal to maximize generation



Harbour with short term storage for hydrogen gas.



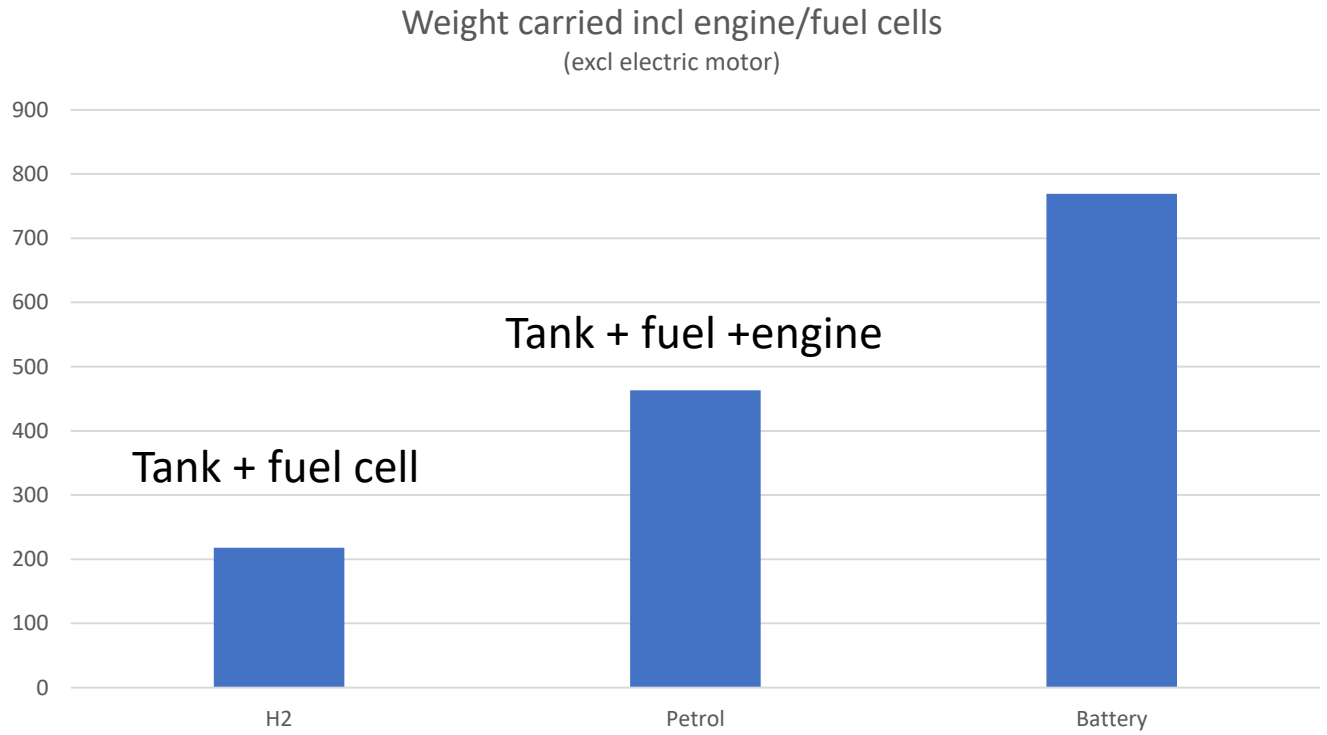
Floating sub-station with conversion facility. Collects electricity from wind farm and converts into hydrogen gas

The first CNG vessel, ***Jayanti Baruna :***

The new 2,200 cubic meter-capacity ship carries compressed rather than liquefied gas, and at a very high pressure of 200 bar (2,900 psi). It is also powered by gas, using a 9-cylinder Wärtsilä 34DF dual-fuel main engine driving a Wärtsilä controllable-pitch propeller to give a service speed of 14 knots.
CNG is considered a more economical alternative to LNG when short distances are involved

# of 7 MW wind power units	184	
Average power produced at 50% capacity factor	644	MW
Amount H2 at 78% electrolyser efficiency	502	MW
Duration of one carrier load of 27 MNm3 H2 for a 500 MW power plant	8	days

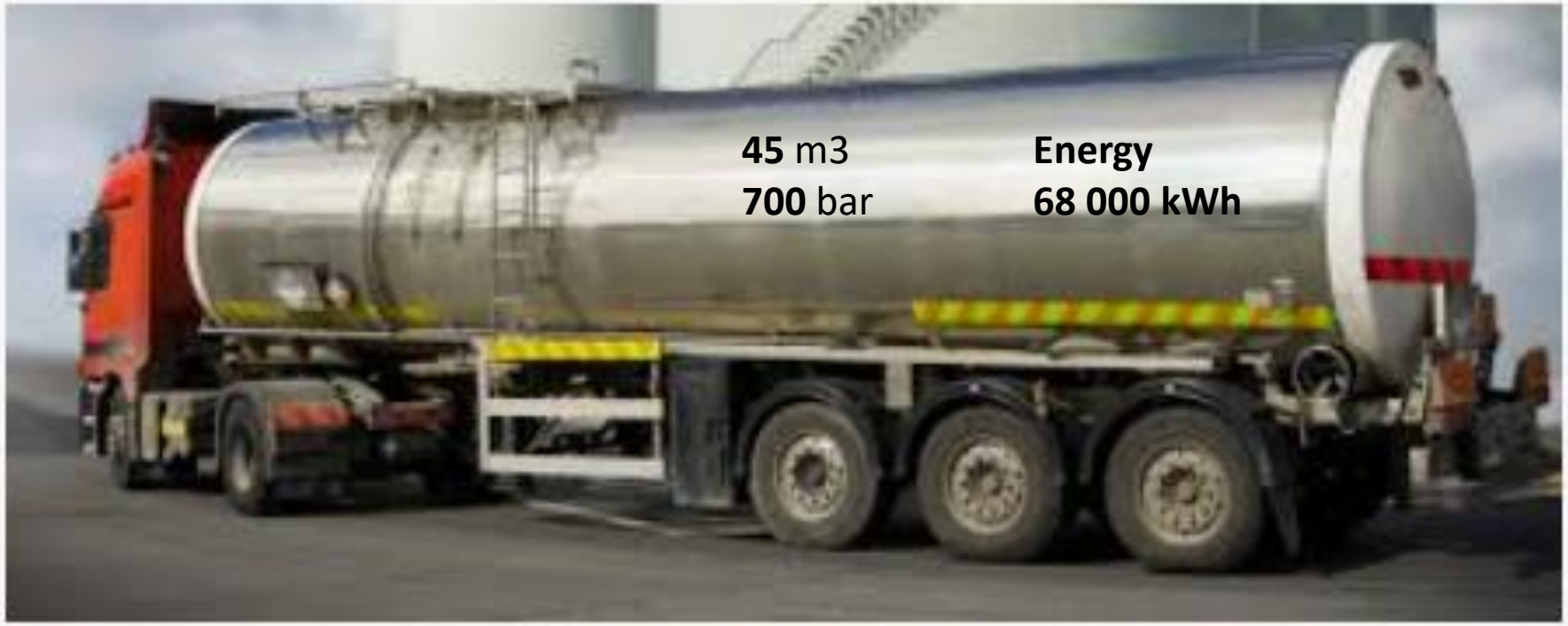
The weight of energy in a car (ref 50 lit petrol)



H2 using fuel cells
Weight is including tank

For heavy trucks the H2 superiority is so much bigger

Truck load to fueling station

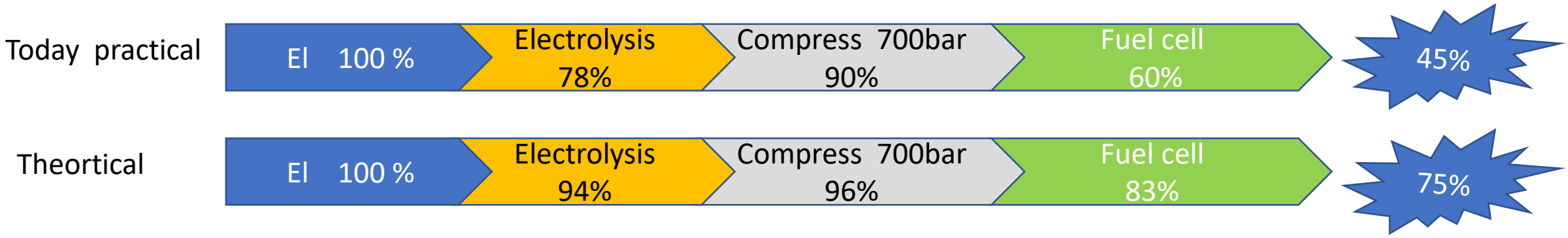


Average gasoline fill : 50 lit
Effective energy: 116 kWh

H2 : 68260 kWh x 60% = 41 000 kWh
Effective H2 energy : 116 kWh
cars fuel : 353 cars (if 250 bar: 130 cars)

Efficiency

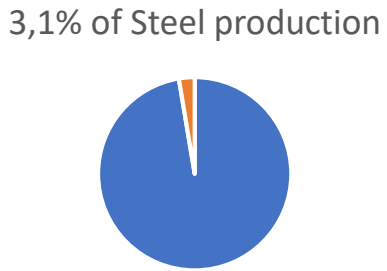
Electricity - to electricity efficiency					
Yield to make H2 in electrolyser	78%	Theoretical in PEM electrolysers			94%
Yield to make it compressed	90%	Theoretical			96,1%
Yield in fuel cells	60%	Theoretical			83%
Total	45,0%				75,0%



In addition: Use the oxygen, use the heat (winter time in cars)

Only 0,15% of ocean needed

World electricity consumption	22500	TWh/år
Energy from offshore windpower/m2	42	KWh
Area needed m2	5,35714E+11	m2
Global ocean area	3,61E+14	m2
% of ocean needed	0,15%	
kg of wind power plants needed	1200 million	ton
Glbal annual production of steel	1800 millions	
Assume 25years of built out		
% of annual steel production	3,1%	



The final global solution ?

- Offshore wind power can generate entire world electricity:
  - 0,15 % of ocean area
  - 706 000 floating units (7MW each)
  - 3,1% of steel production during 20 years
  - Investment equivalent to 0,7 % of world GDP
- Add hydrogen production to also generate fuel (transport,heat, ironmaking etc)
- ”Least amount of material ” - solution

CONCLUSION

It seems that offshore wind can produce el + Hydrogen
which resolves all the global need of electricity and fuel

- without any destruction of earth resources !! Maybe the only solution ,
which also provide sufficient amount ? ??