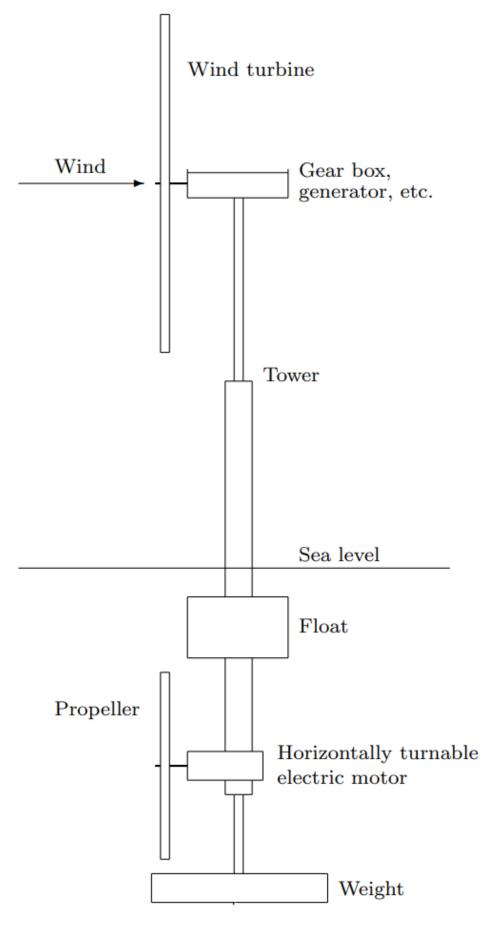
Unanchored Floating Wind Turbines An invention for deep water wind farms

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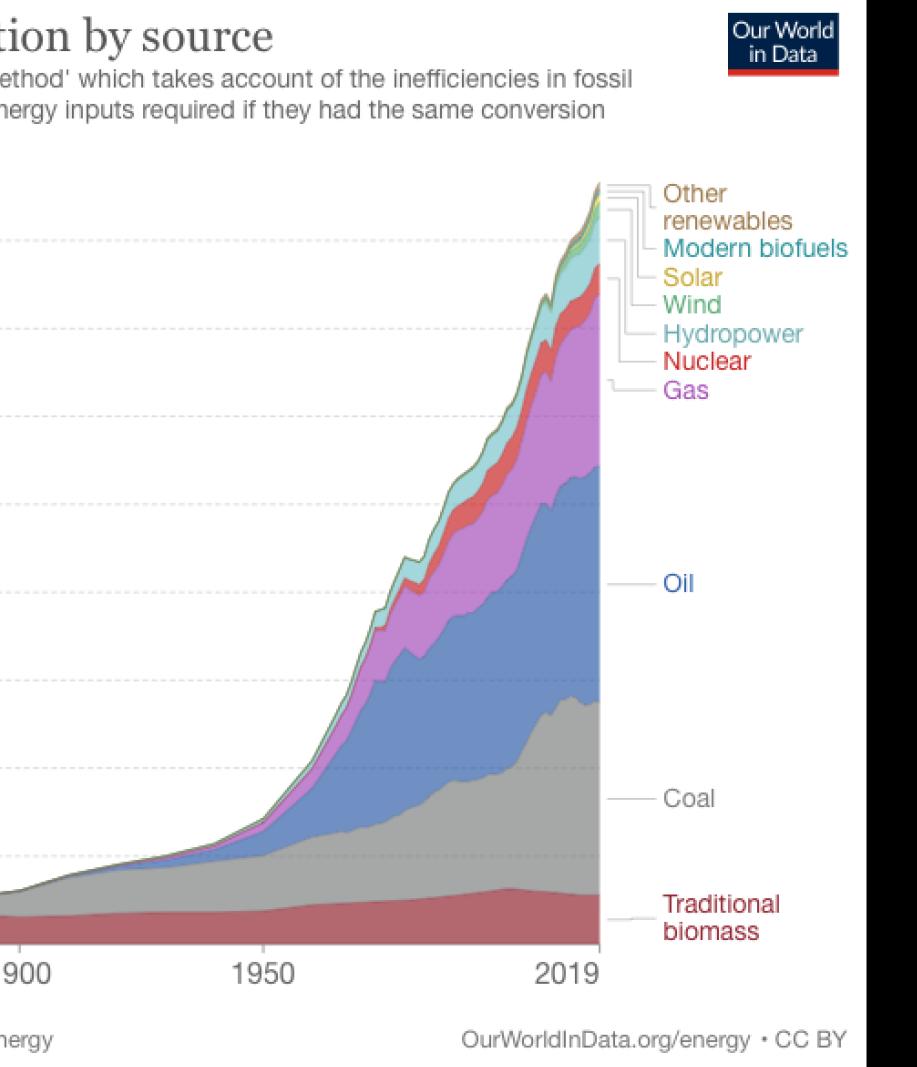
2019: 170,000 terawatt-hours, >80% fossil

Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

0	IVVII	1800	1850	1
0	TWh			
20,000	TWh			
40,000	TWh		 	
60,000	TWh		 	
80,000	TWh			
100,000	TWh			
120,000	TWh		 	
140,000	TWh		 	
160,000	TWh			

Source: Vaclav Smil (2017) & BP Statistical Review of World Energy

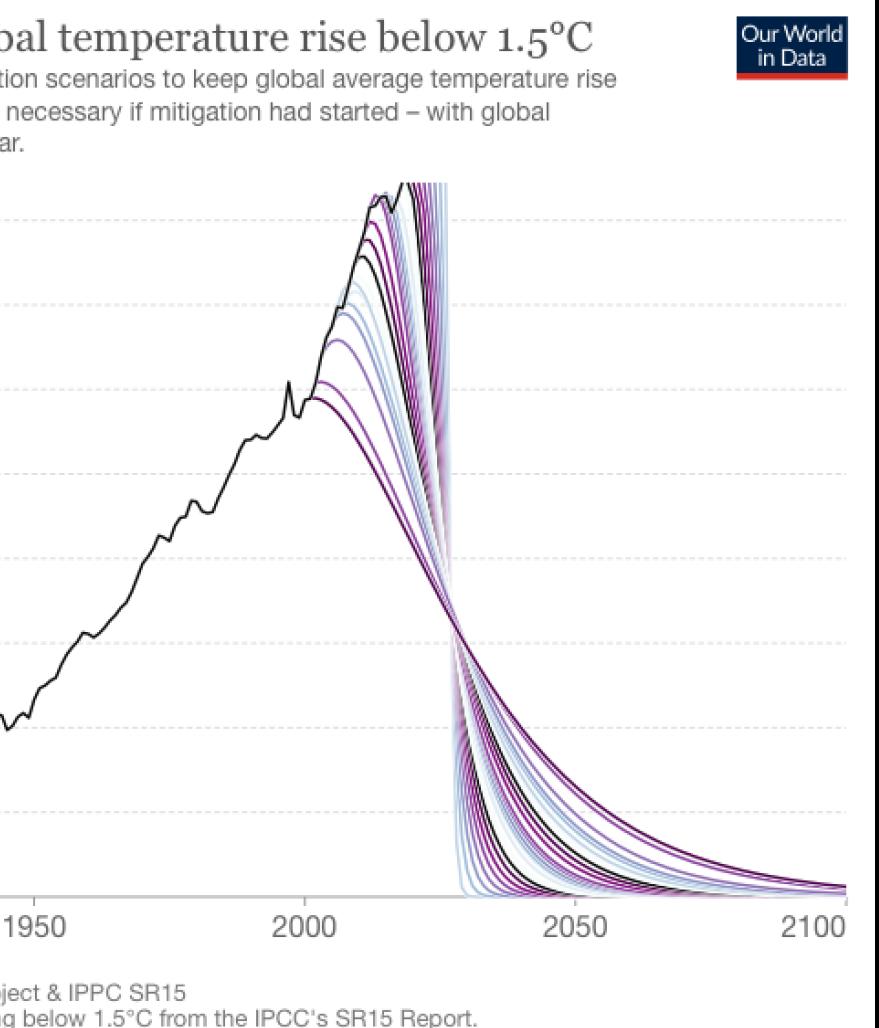


Immediate energy shift needed for 1.5°C

CO₂ reductions needed to keep global temperature rise below 1.5°C

Annual emissions of carbon dioxide under various mitigation scenarios to keep global average temperature rise below 1.5°C. Scenarios are based on the CO₂ reductions necessary if mitigation had started – with global emissions peaking and quickly reducing - in the given year. 40 billion t 35 billion t 30 billion t 25 billion t 20 billion t 15 billion t 10 billion t 5 billion t 0 t 1900 1850

Source: Robbie Andrews (2019); based on Global Carbon Project & IPPC SR15 Note: Carbon budgets are based on a >66% chance of staying below 1.5°C from the IPCC's SR15 Report. OurWorldInData.org/co2-and-other-greenhouse-gas-emissions · CC BY



Can we deploy renewables quick enough?

NASA Blue Marble by NASA Goddard Space Flight Center





covered by oceans

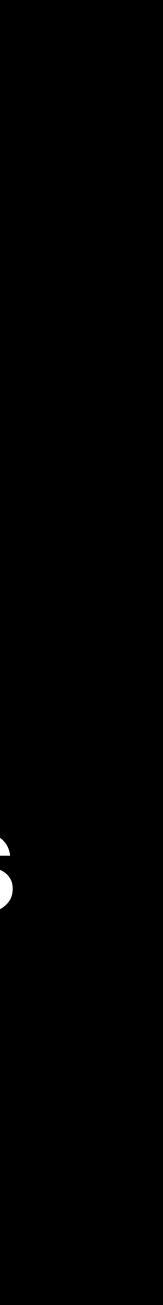


"wind power generation over some ocean areas can exceed power generation on land by a factor of three or more"

Possner, A. & K. Caldeira. (2017). Geophysical potential for wind energy over the open oceans. PNAS.



Sundman: Deep water wind farms made of unanchored, free floating turbines



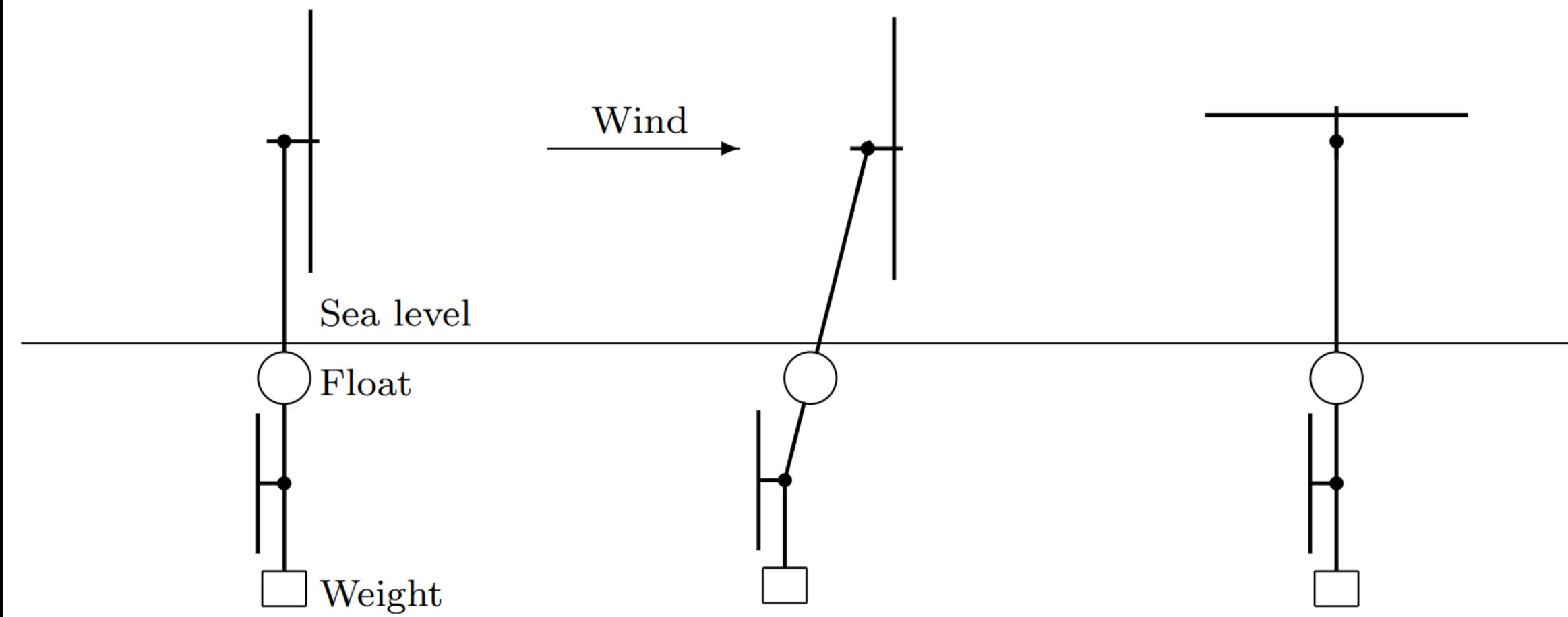
Early Testing & Prototyping in 1980s





US, EU & FI Patents Granted, Released to Public in 1994

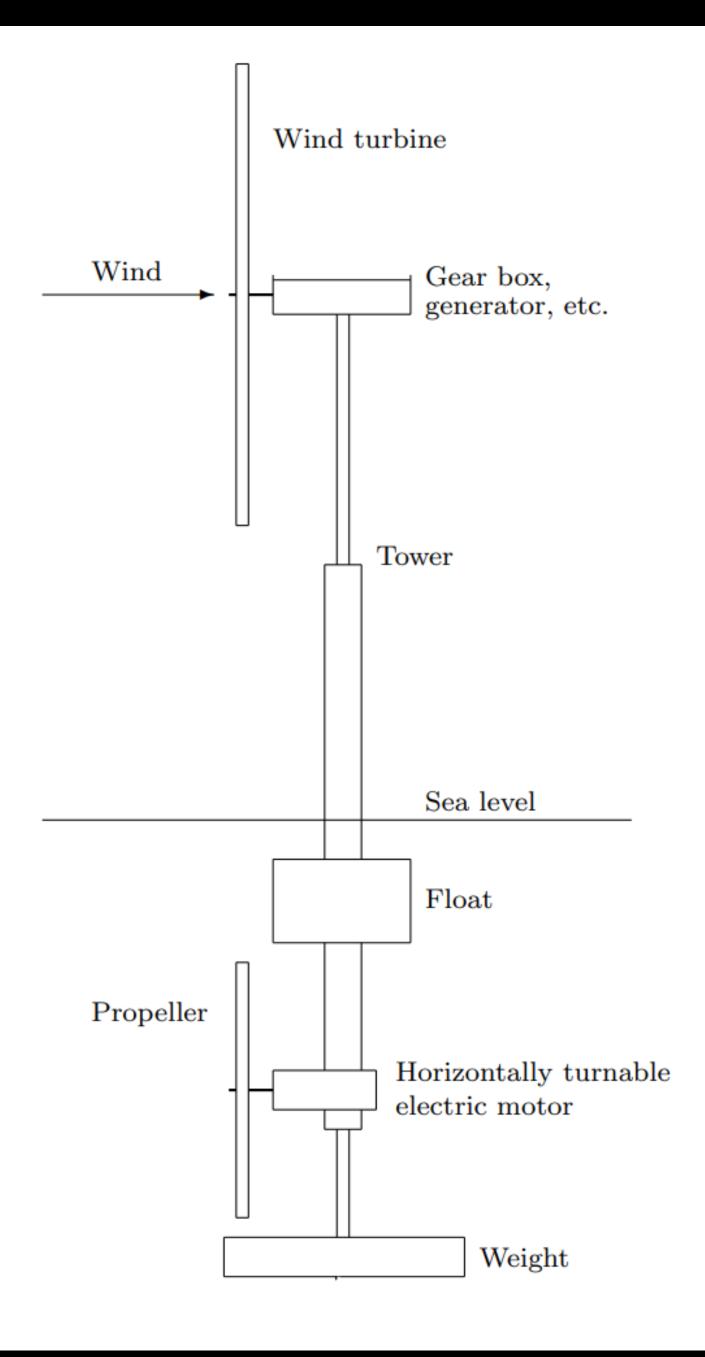
2010s: Invention Refined



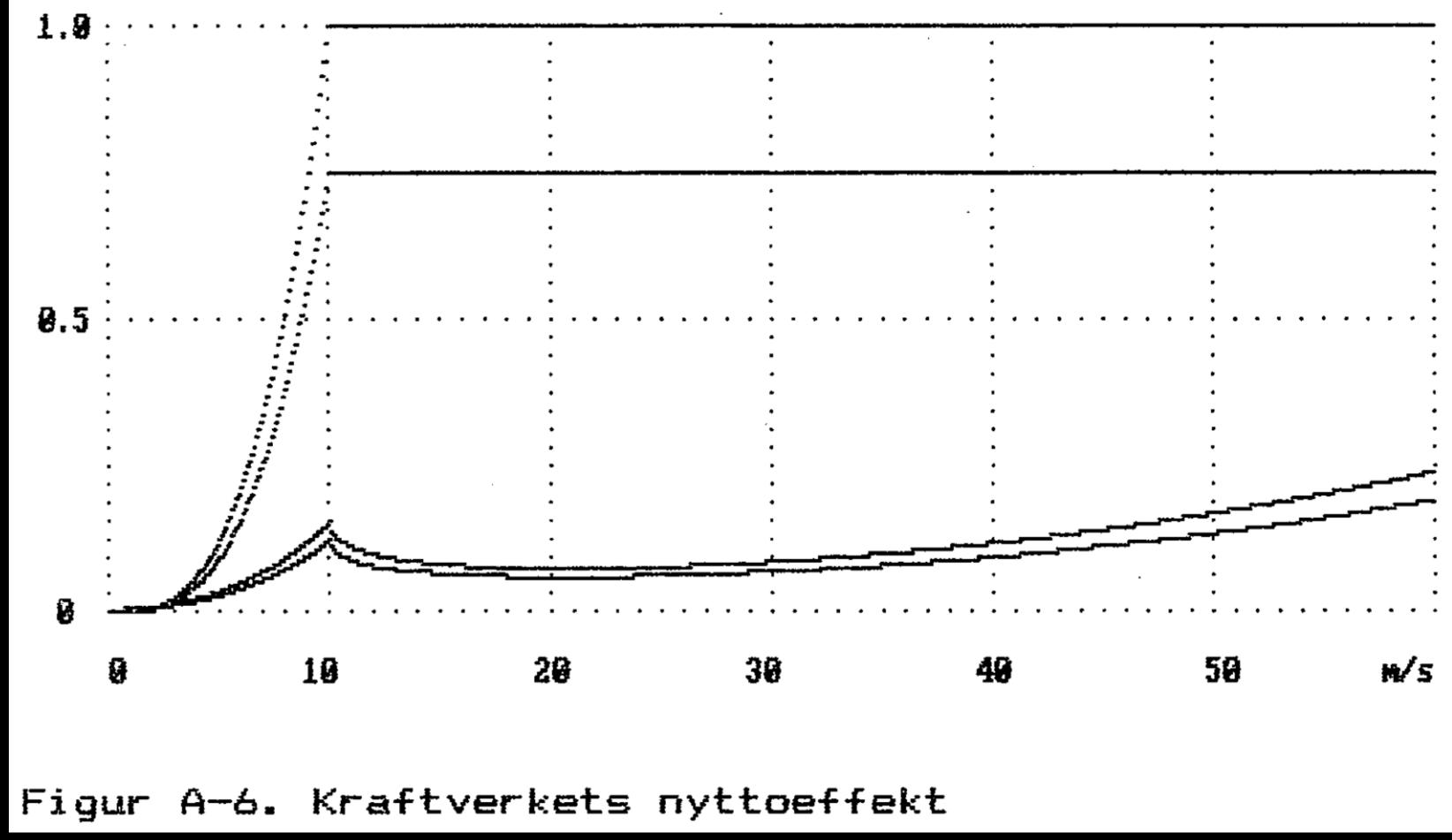


2010s Invention Refined

- Unanchored, floating unit
- Slender & needle-shaped
- Not rigid flexes under wind
- Relatively small material footprint
- Turbine and propeller: two-bladed fast runners
- Propeller holds unit in place, can float out of position under storm conditions and then return

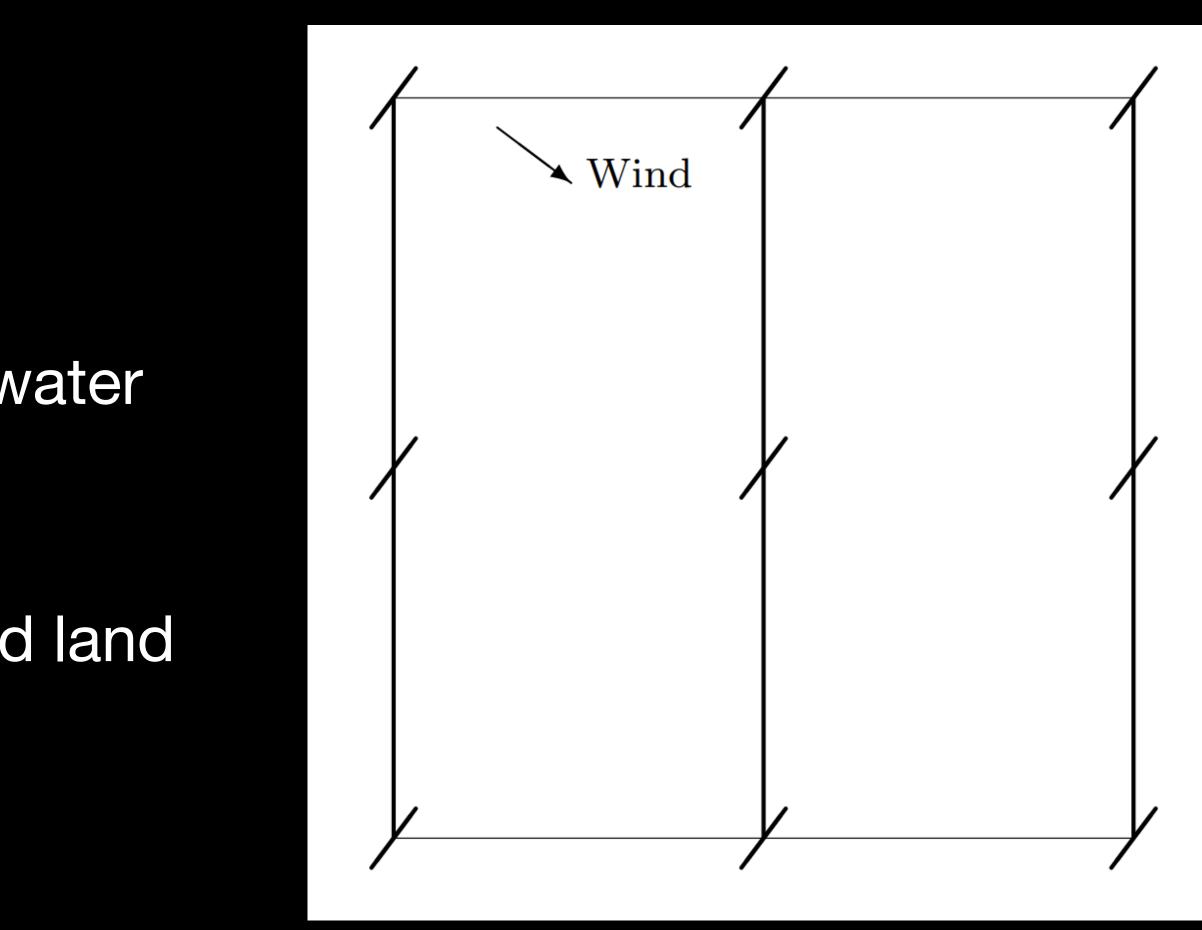


Turbine's Theoretical Net Energy Production

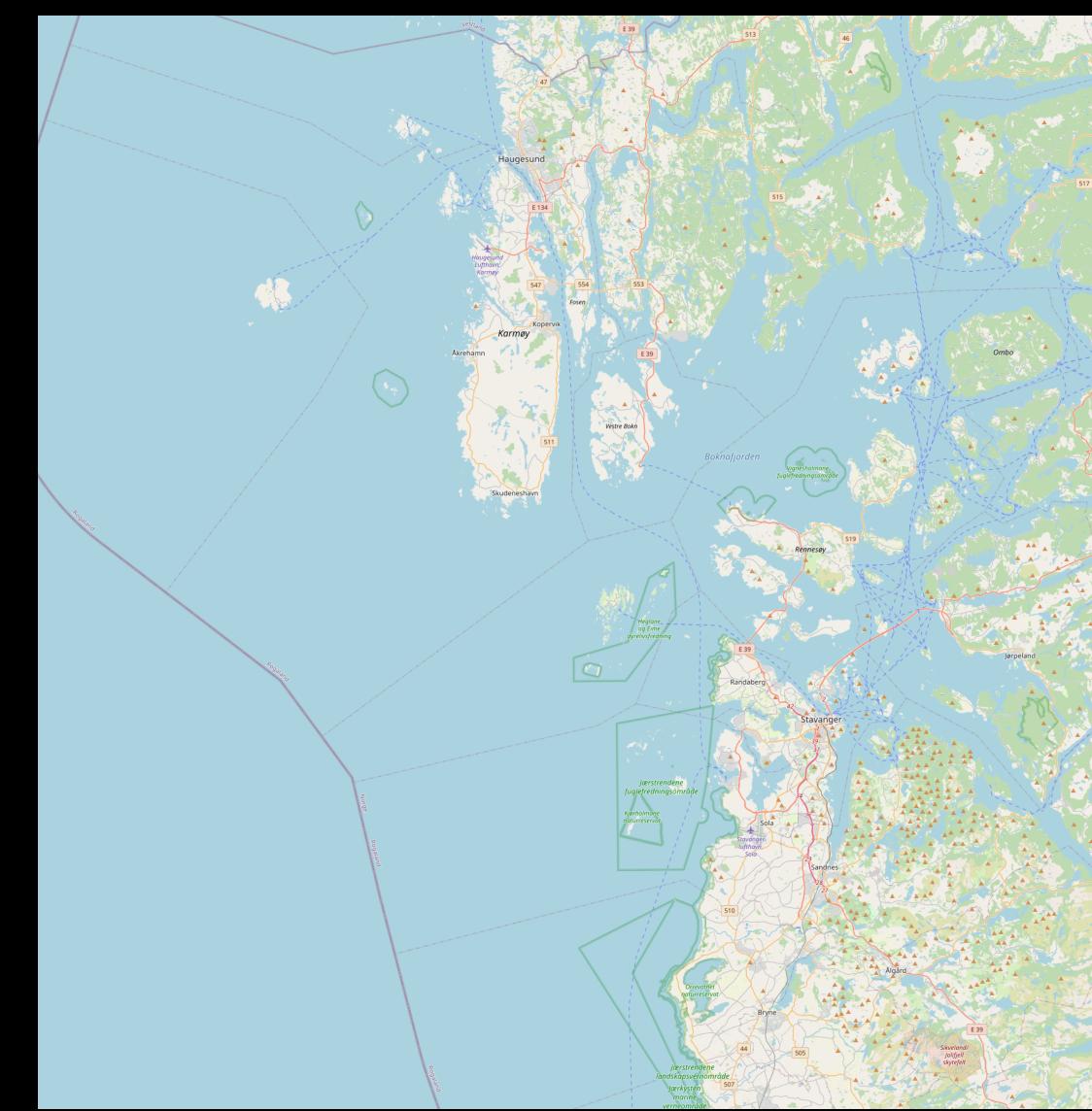


Wind Farm Turbines Joined Together at Sea

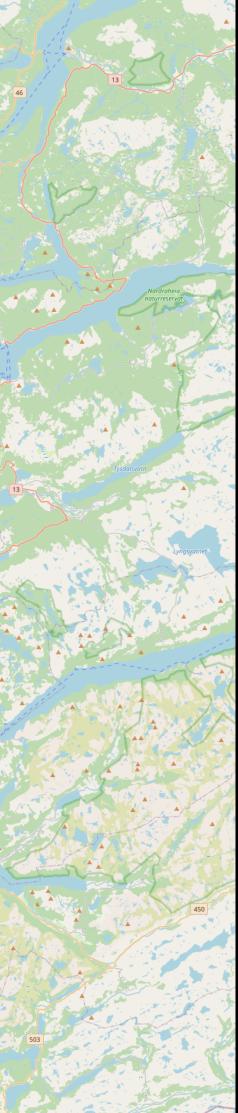
- Green hydrogen via electrolysis of water
- —> climate-neutral hydrocarbons
- May be used in existing air, sea, and land transportation fleets

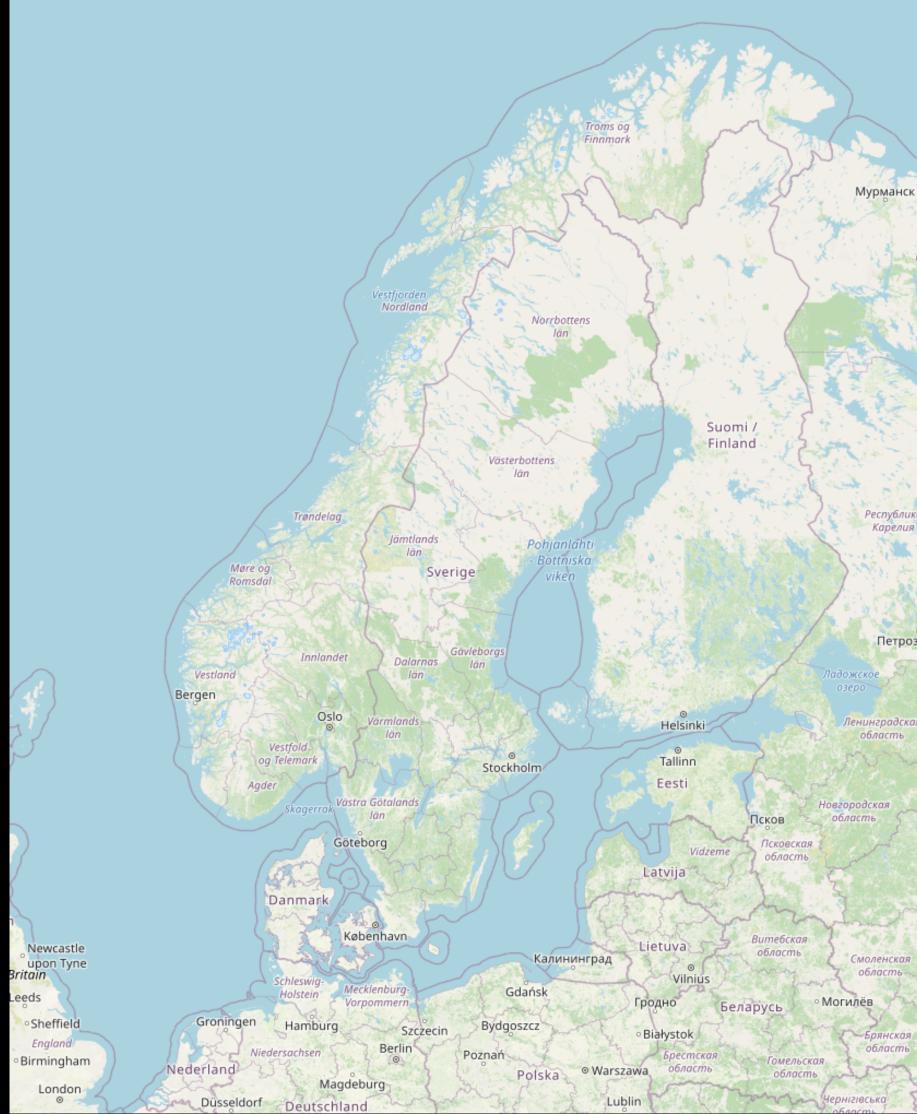


Call for construction and real-world testing of a prototype at scale

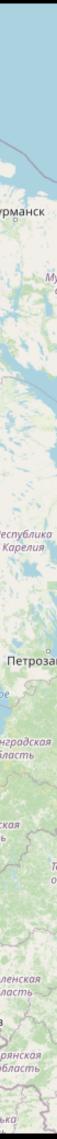


Bokna Fjord, Stavanger, and surrounding areas © Open Street Map





Norway, Northern Europe, and surrounding region © Open Street Map



Who would like to take it further?

Thank you

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