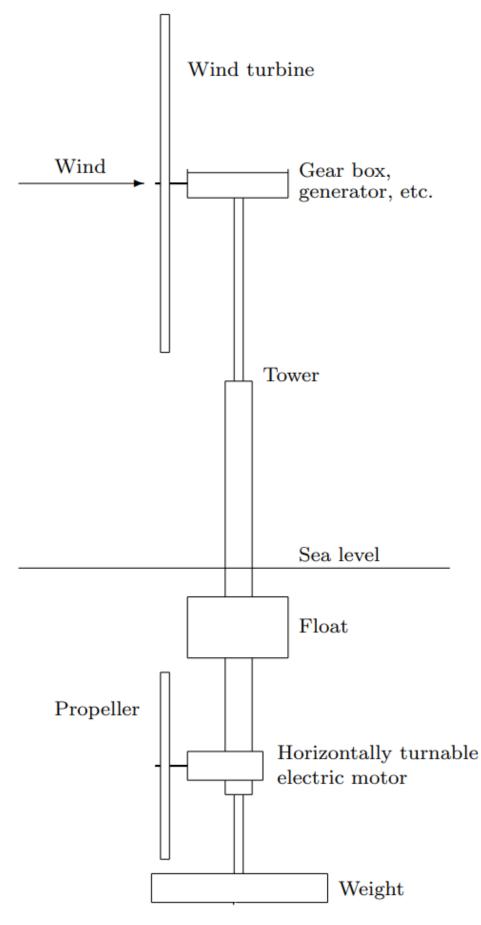
#### **Unanchored Floating Wind Turbines** An invention for deep water wind farms

Jack H. Raisanen Atmospheric Sciences MSc Student // INAR // University of Helsinki Independent Environmental & Sustainability Consultant

Stig Sundman, MSc Independent Inventor & Engineering Physicist Helsinki, Finland





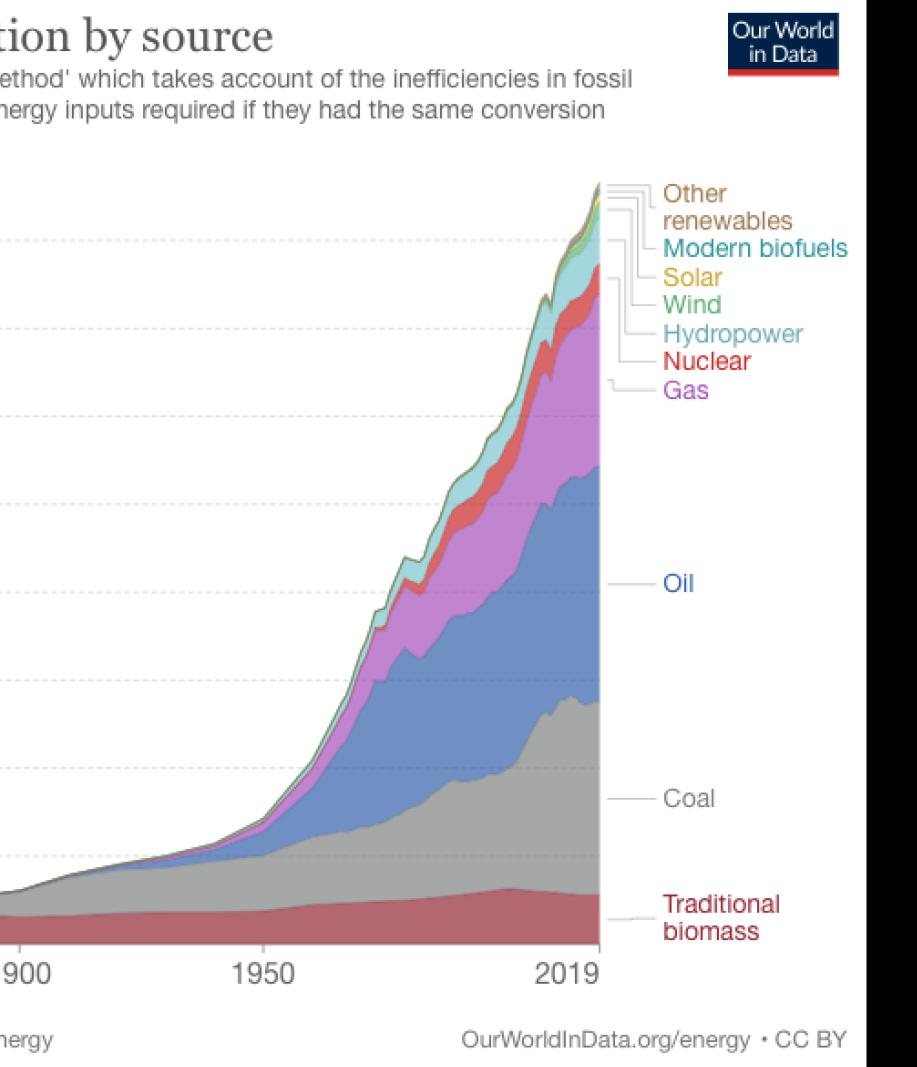
#### 2019: 170,000 terawatt-hours, >80% fossil

#### 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

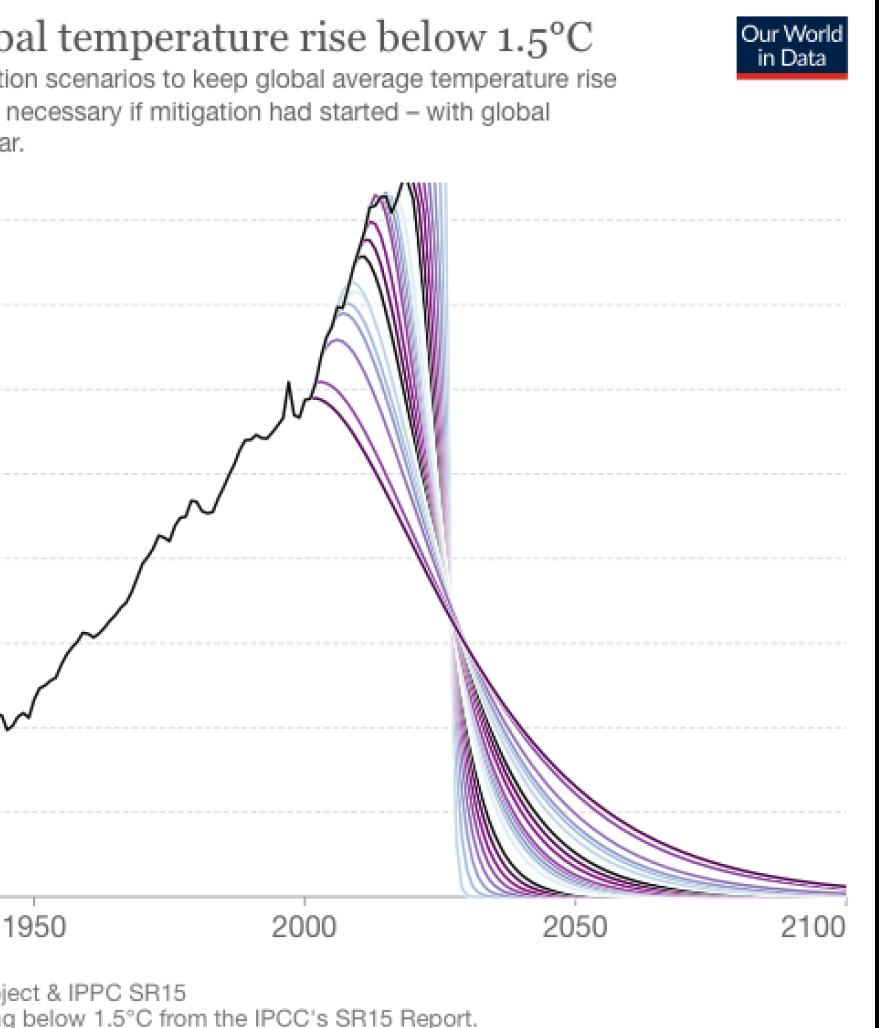


#### Immediate energy shift needed for 1.5°C

#### CO<sub>2</sub> 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 CO<sub>2</sub> 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

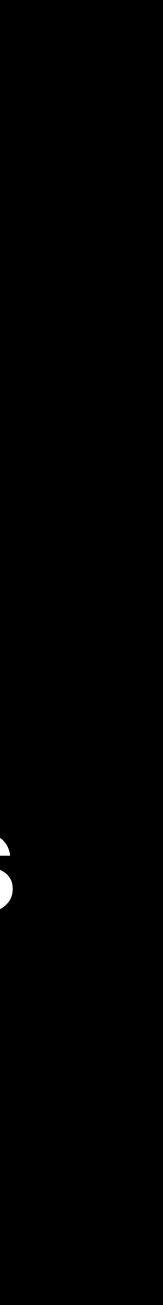


#### "wind power generation over some ocean areas can exceed power generation on land by a factor of three or more"

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



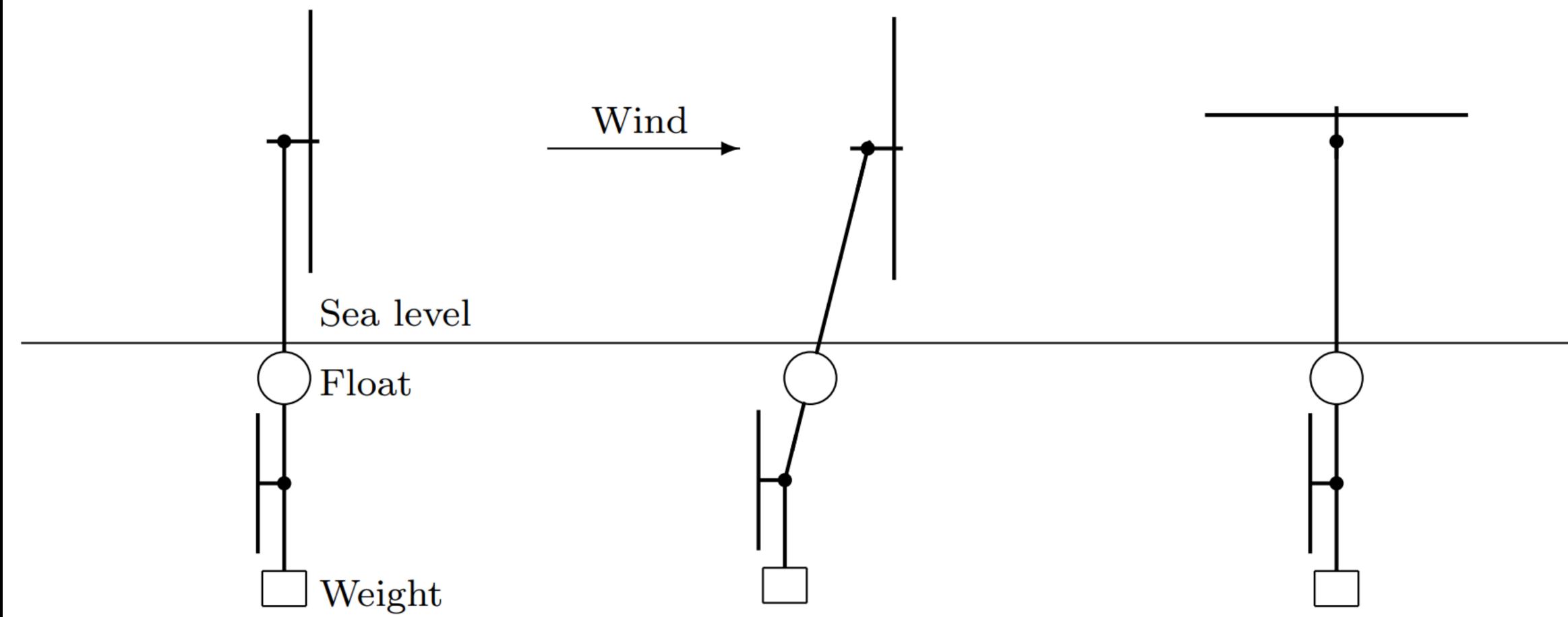
### Early Testing & Prototyping in 1980s





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

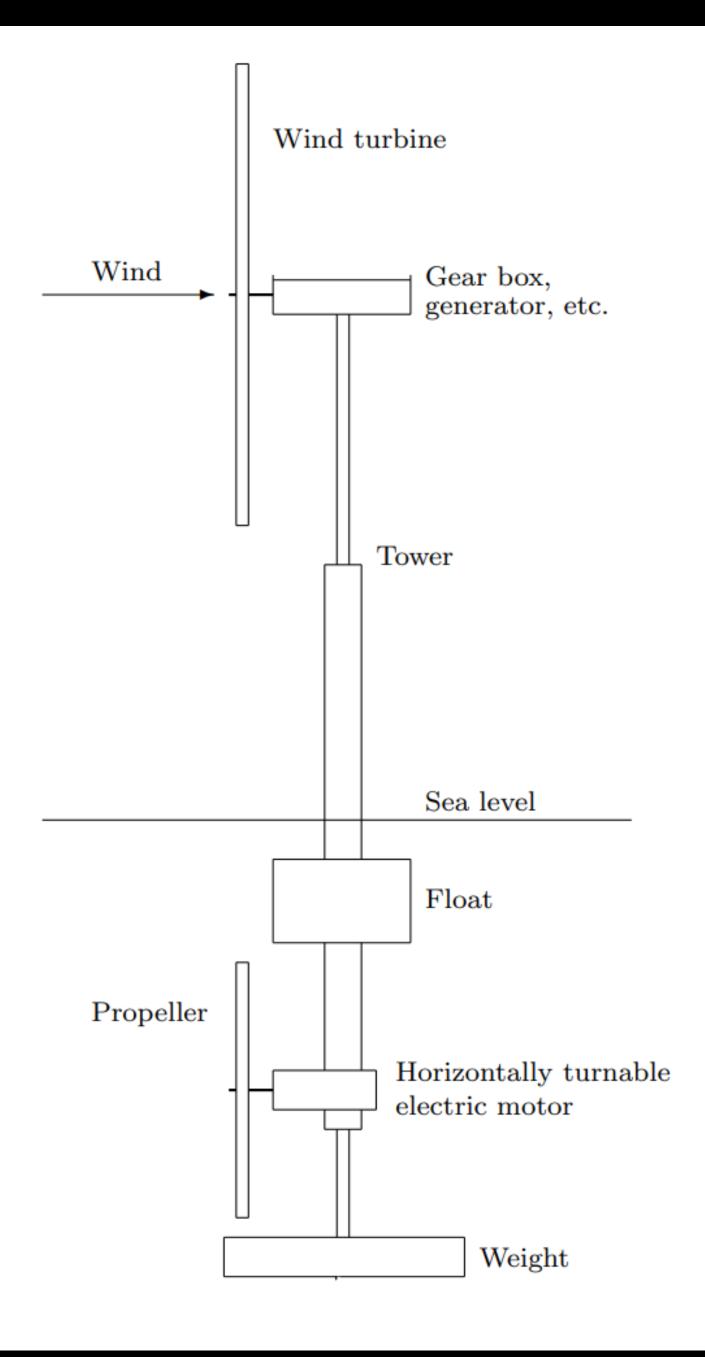
#### **2010s: Invention Refined**



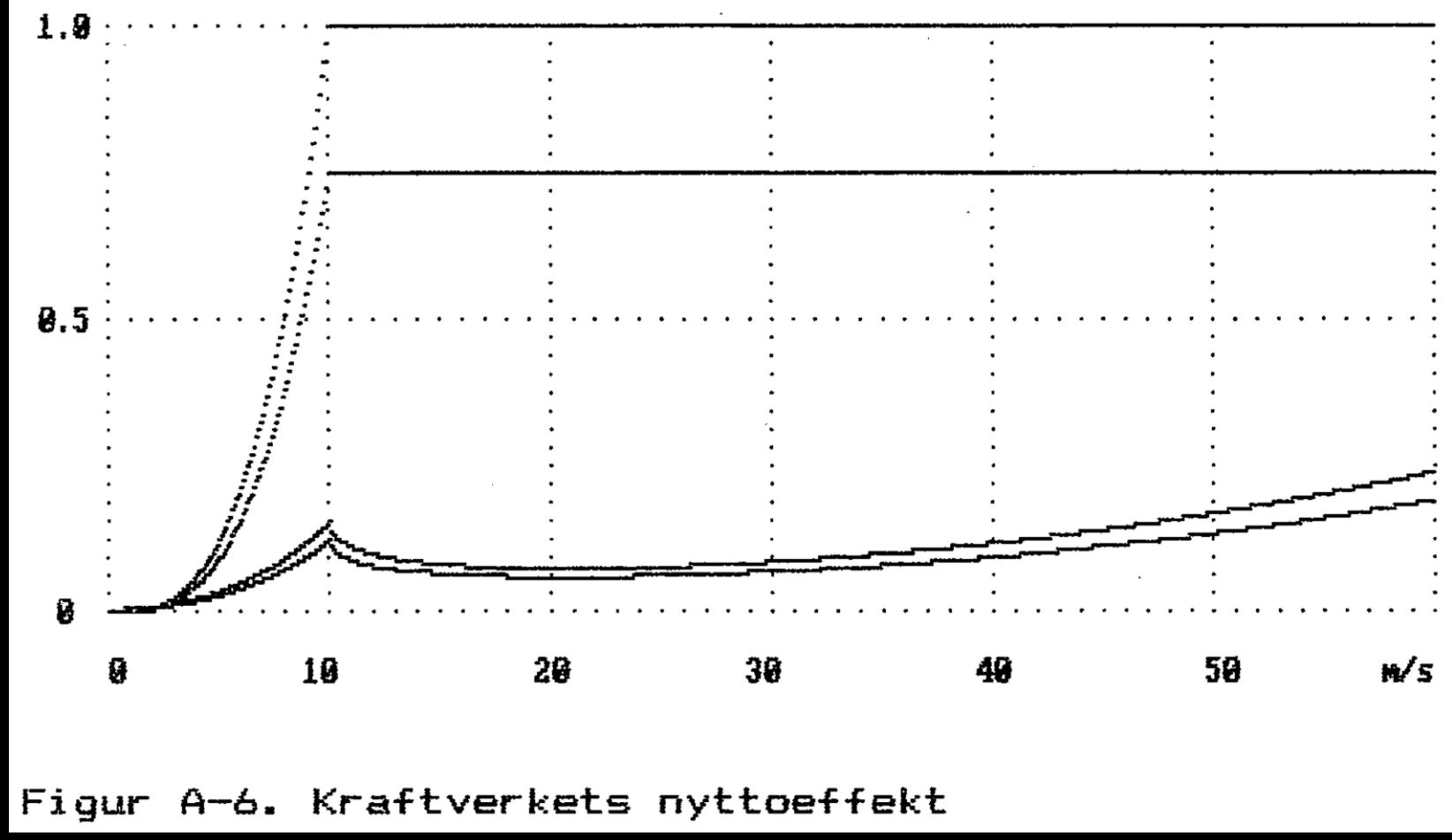


#### 2010s Invention Refined

- 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

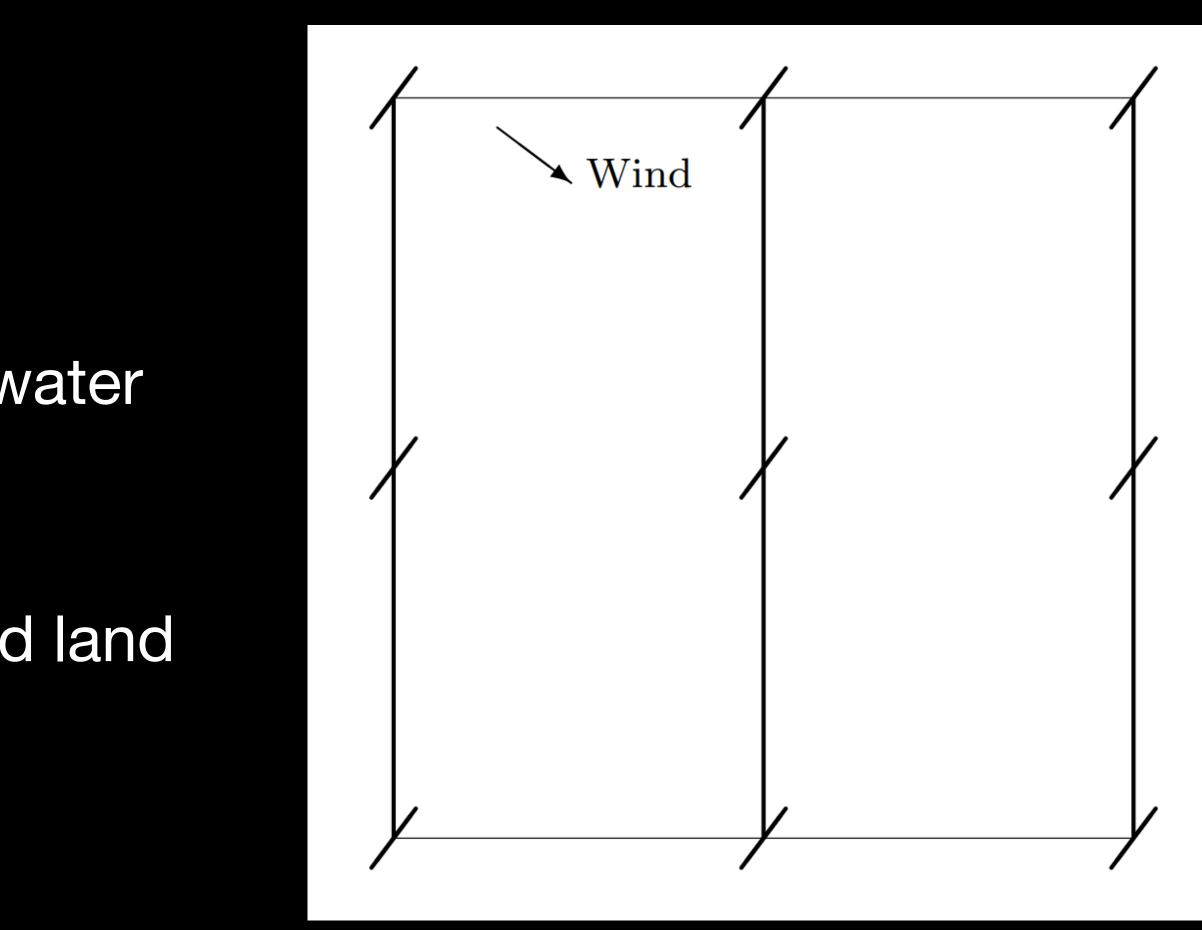


### **Turbine's Theoretical Net Energy Production**

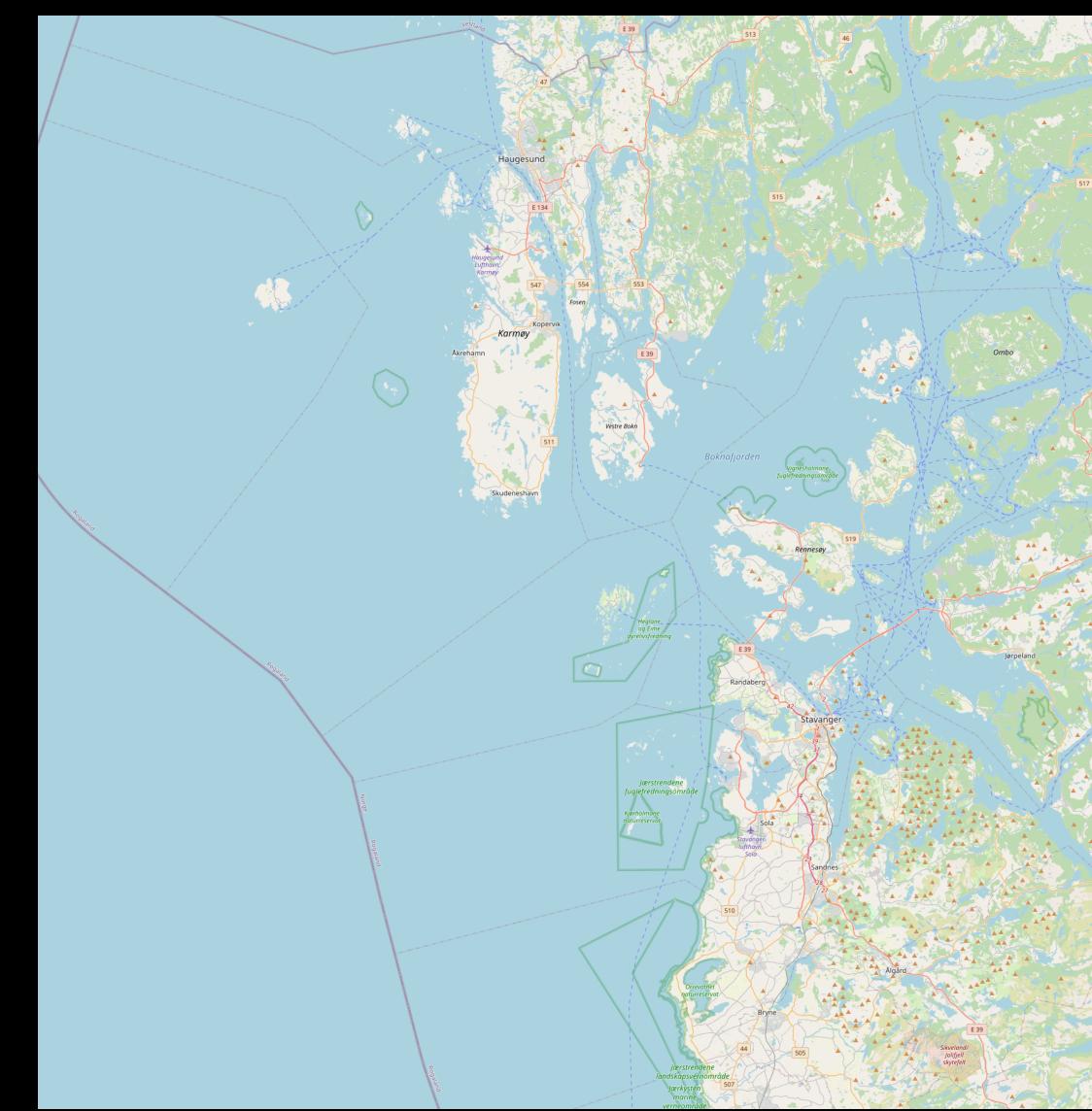


#### Wind Farm Turbines Joined Together at Sea

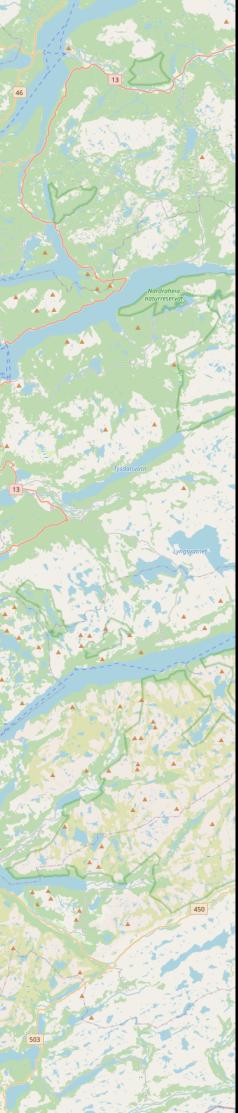
- Green hydrogen via electrolysis of water
- —> climate-neutral hydrocarbons
- May be used in existing air, sea, and land transportation fleets

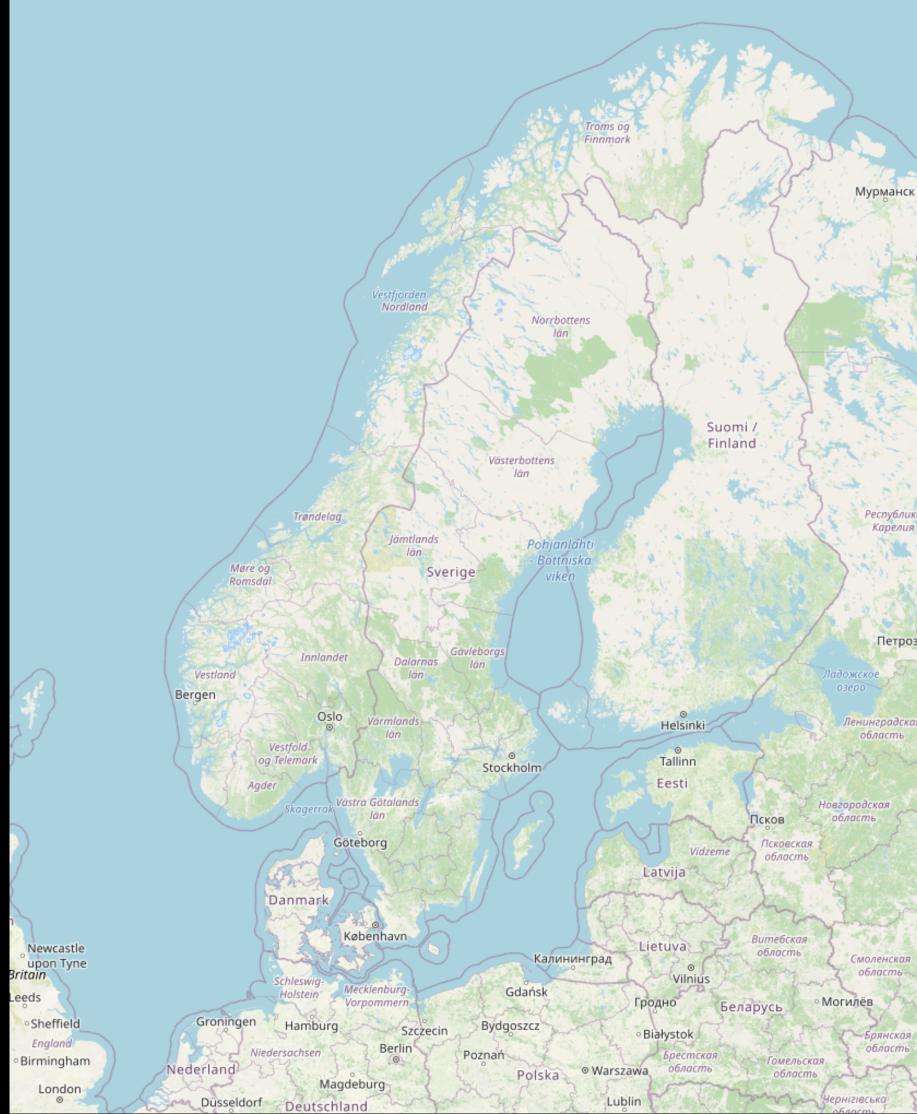


# Call for construction and real-world testing of a prototype at scale

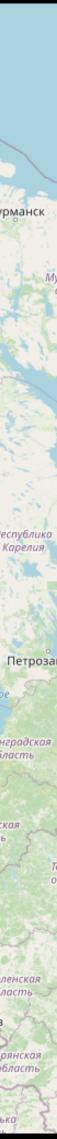


Bokna Fjord, Stavanger, and surrounding areas © Open Street Map





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



# Who would like to take it further?

## Thank you

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