

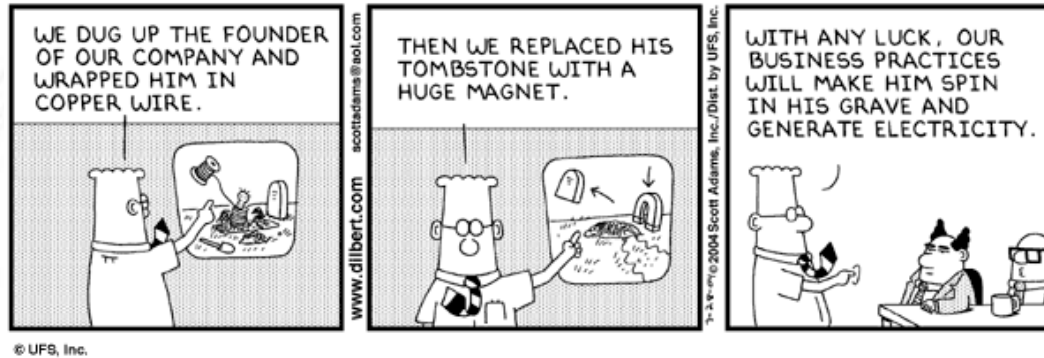
Rain cells: Production of electricity directly from raindrops

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The society needs more electrical energy



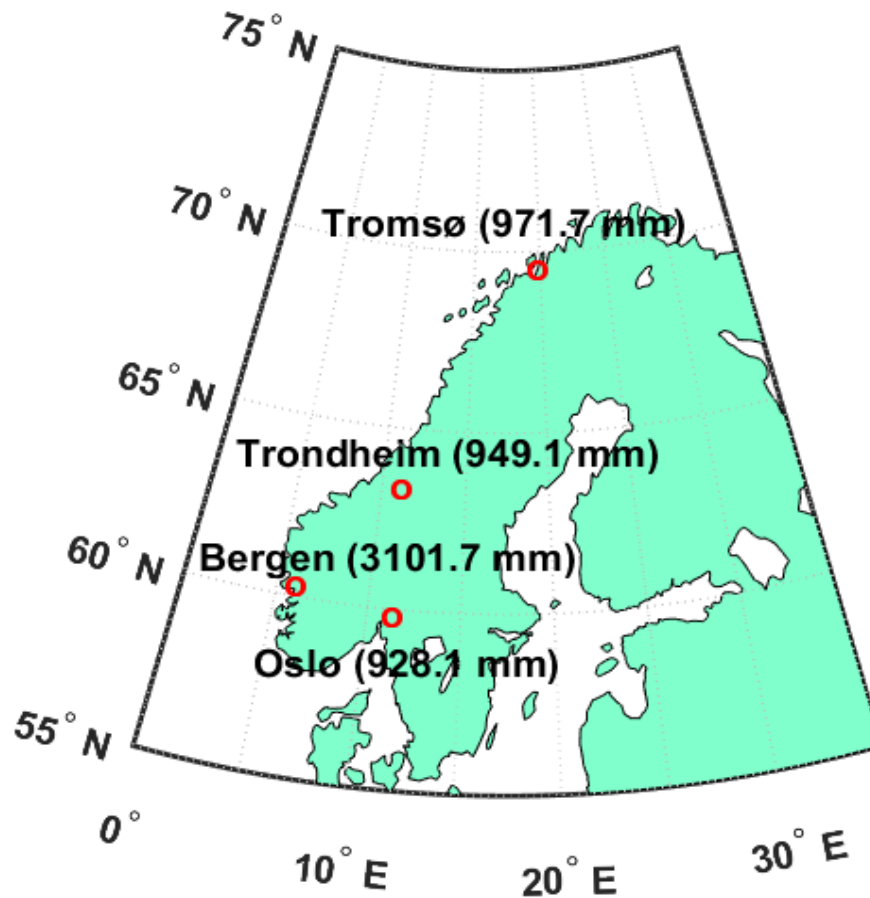
Large scale energy harvest for homes and communities ($> 1\text{kW}$)

- Hydropower: waterfalls with electromagnetic hydroturbines (perhaps 99% in Norway)
- Solar power
- Wind power ($> 30\%$ in Denmark)
- Reverse osmosis power plants
- Geothermal energy
- Sea wave and tidal power plants

Small scale energy harvest for autonomous sensors ($< 10\text{ W}$)

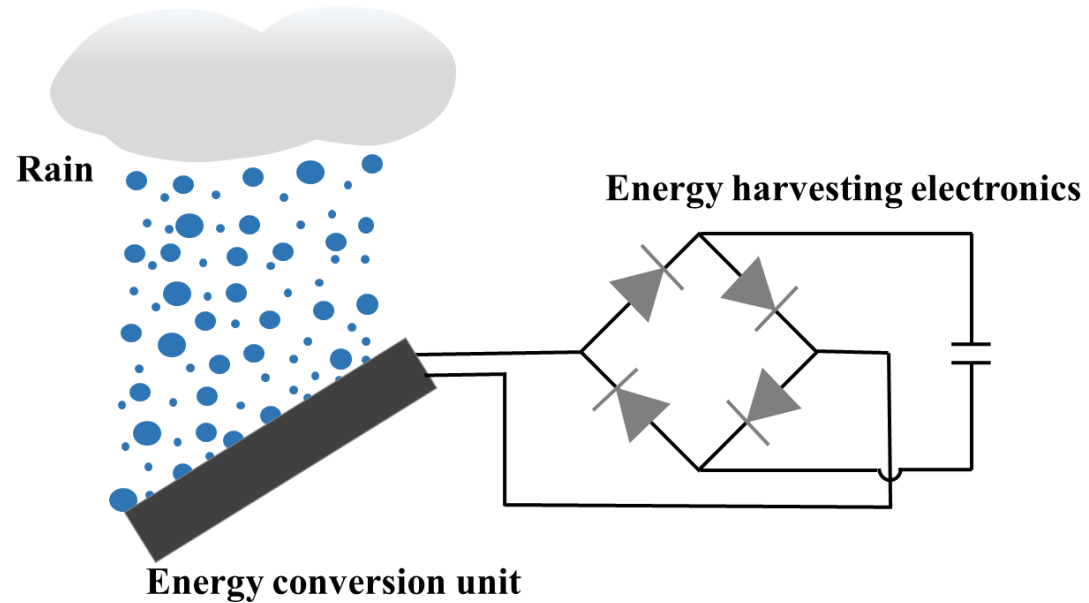
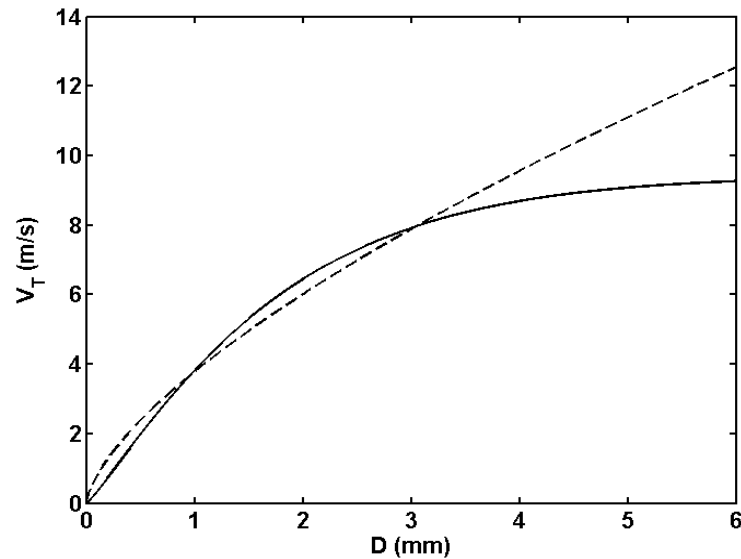
- Solar cells (photovoltaic)
- Thermoelectric generators
- Pyroelectric generators
- Electromagnetic generators
- Microwave generators
- Piezoelectric generators
- **Contact electric nanogenerators powered by kinetic energy of water or solid objects**

Bergen has a lot of rain!



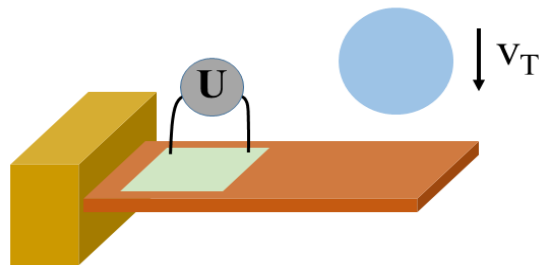
The 2015 data is retrieved from the Norwegian Meteorological Institute (<http://eklima.met.no>)

Can we transform the mechanical energy of raindrops directly into electrical energy?



Current promising rain cell technologies

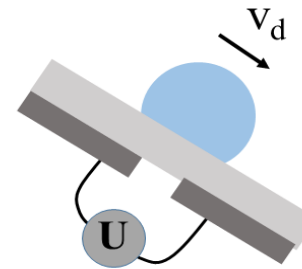
Piezoelectric transducer



- Clamp
- Elastic support
- Piezoelectric material

- Need elastic platforms
- High voltage, low current

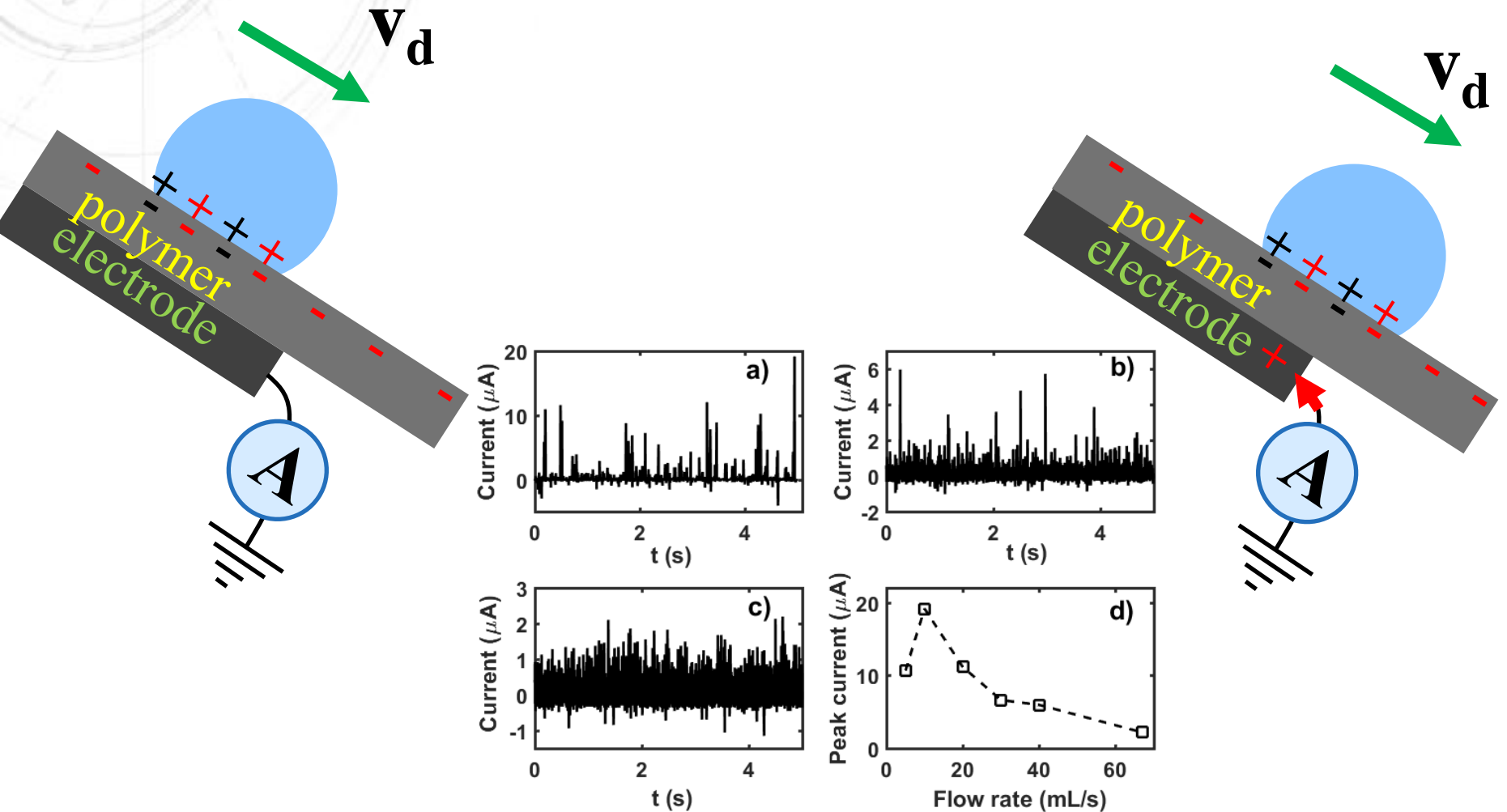
Triboelectric transducer



- Hydrophobic polymer
- Metal electrode

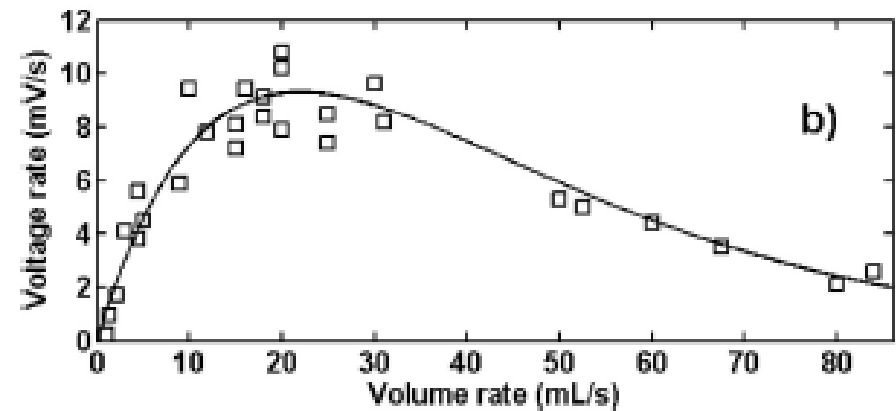
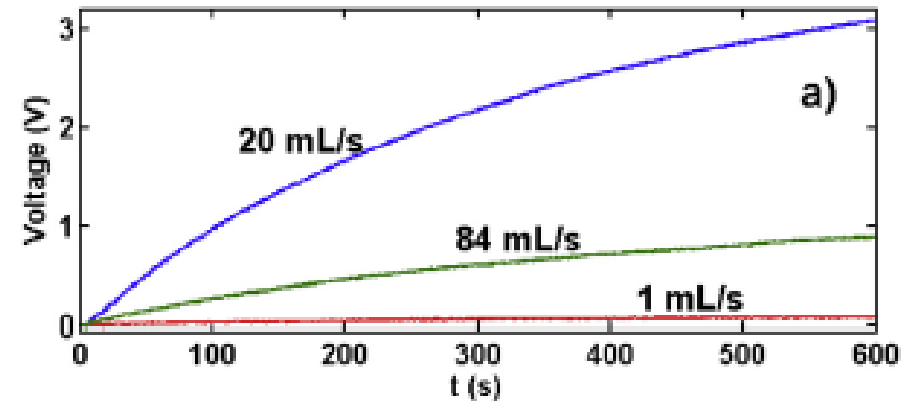
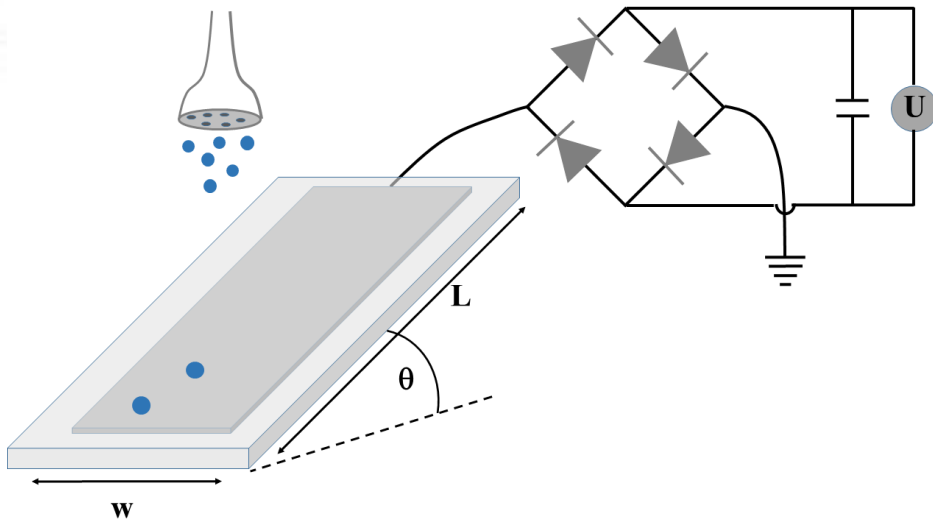
- The polymer film is strongly water/oil repelling, and can **protect** and **generate power** at the same time
- High voltage, low current

Triboelectric transducer: Example



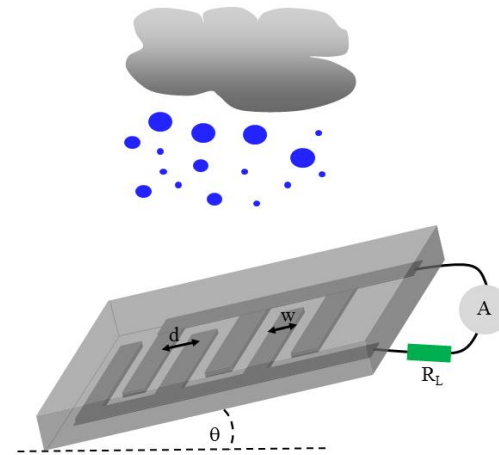
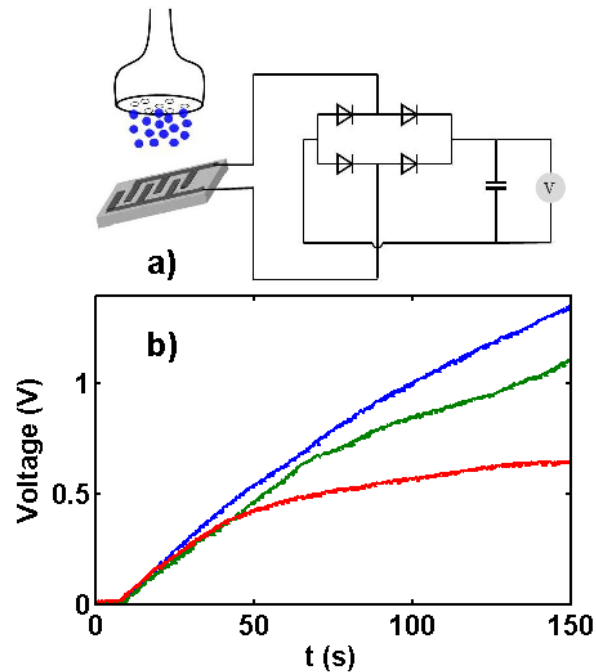
L.E. Helseth and X.D. Guo, *Renewable Energy*, 2016 ;Volume 99. s. 845-851

Rain cell: Influence of volume rate



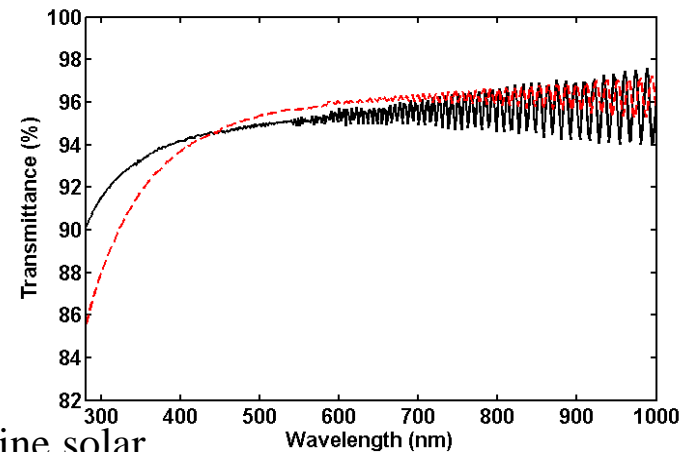
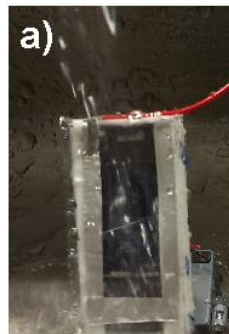
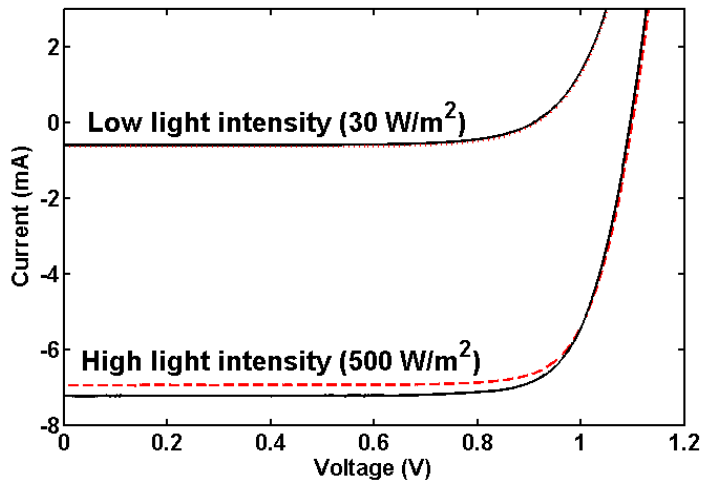
L.E. Helseth, Journal of Electrostatics 2016 ; Volum 81. s. 64-70

Rain cell: Influence of electrode geometry

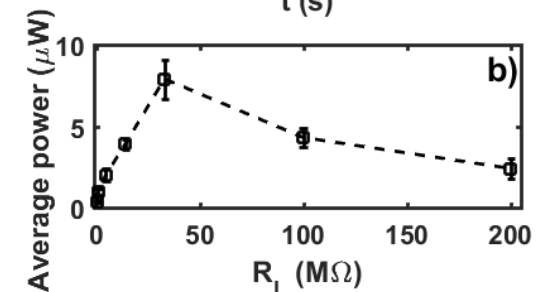
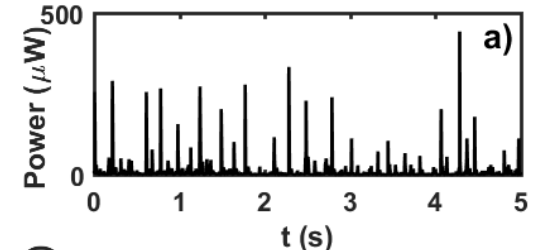
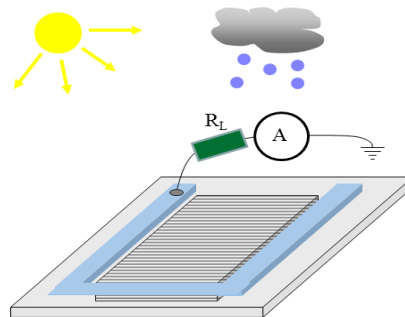
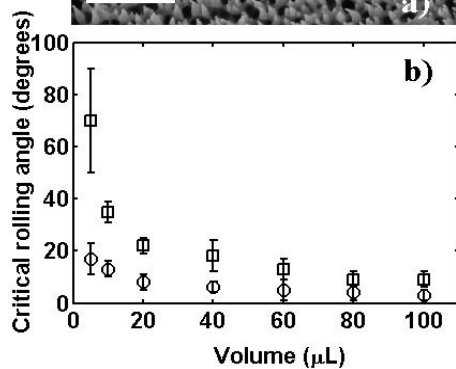
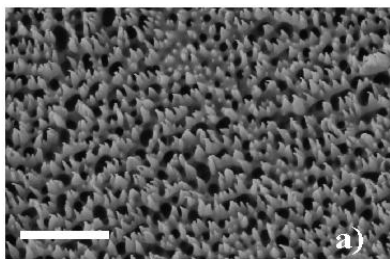


L.E. Helseth X.D. Guo, Smart materials and structures, 2016 ;Volum 25:045007

Combining solar cells and rain cells

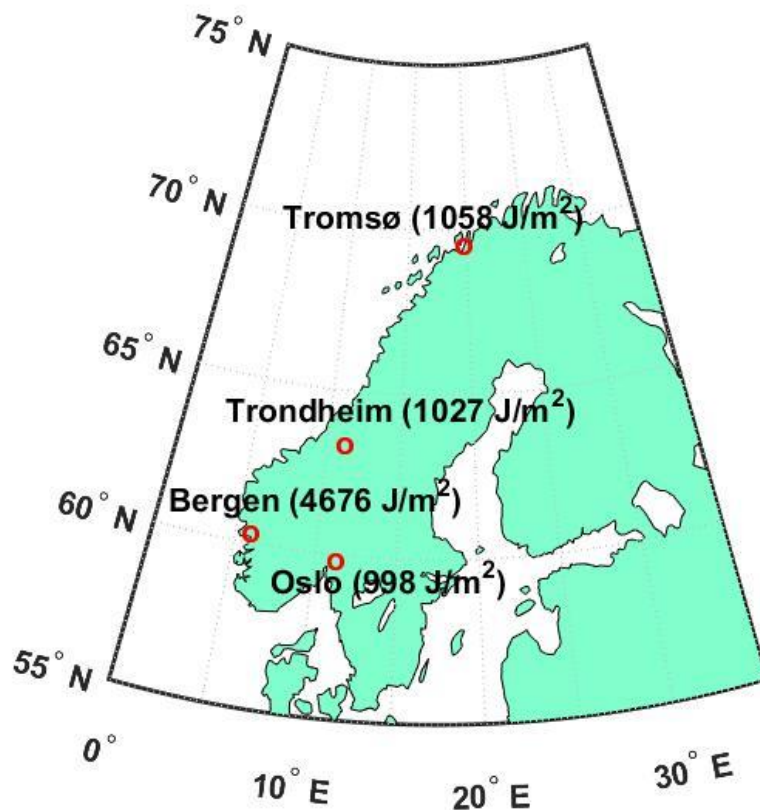


Commercial polycrystalline solar cell with efficiency about 9%



L.E. Helseth and X.D. Guo, *Renewable Energy*, 2016 ;Volume 99. s. 845-851

Potential of rain cells



L.E. Helseth, and H.Z. Wen, *Energy*, 2017 ;Volum 119. s. 472-482

Rain intensity transformed into electrical energy assuming 9% efficiency. Used 2015 rain intensity data from Norwegian Meteorological Institute (<http://eklima.met.no>) to calculate energy.

Thank you for listening!

