



Role of Technology in Reducing CO₂ to Zero

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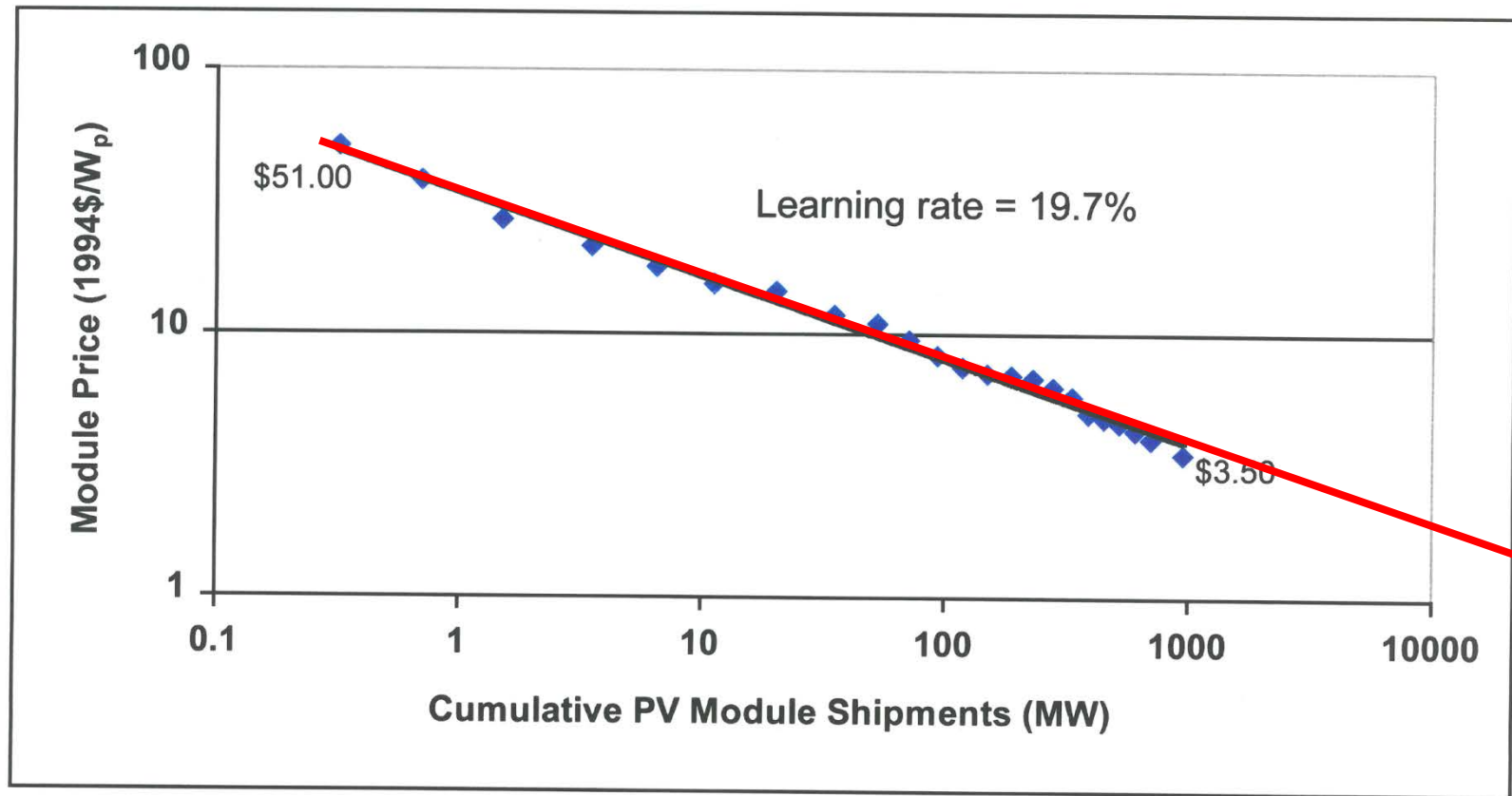
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Vienna University of Technology

*15th IAEE European Conference 2017, Heading Towards Sustainable
Energy Systems, Evolution or Revolution, Vienna – 3-6 September 2017*

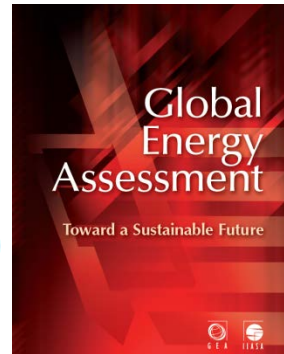
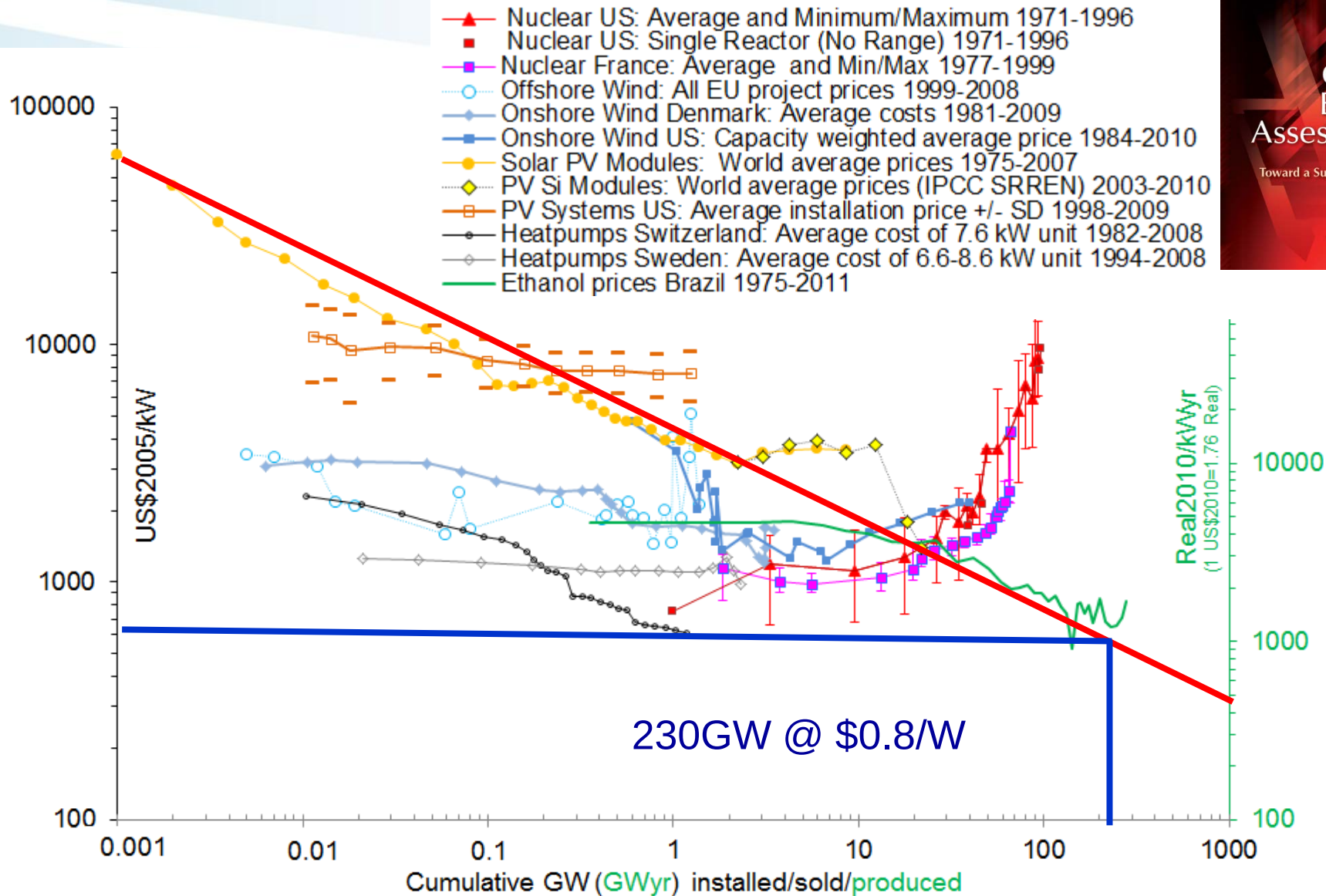
Solar PV Modules 1976–1998

(Harmon, 1999)

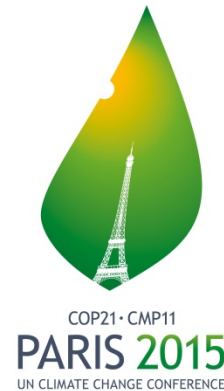


Data: Ayres (1998), Thomas (1999), Williams and Terzian (1993)

Supply Technologies Cost Trends



The Paris Agreement



Bildquelle: <https://www>

Limiting global
warming to
“well below”
2 degrees celsius

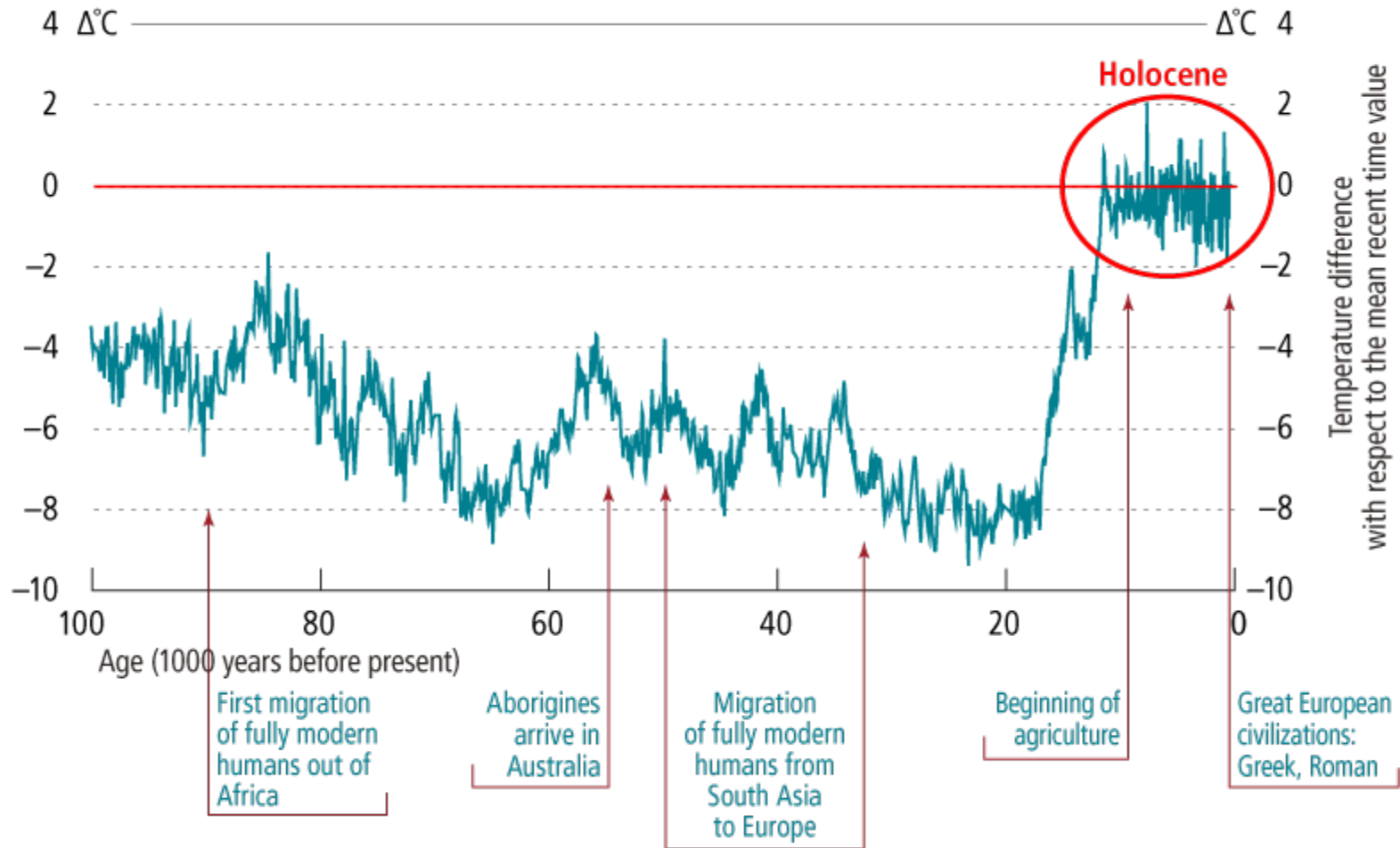
Achieving **net-zero**
GHG emissions by mid of
the 21st century

Regular review and
improvement of **nationally**
determined contributions

Mobilizing **\$100**
billion a year in
support by 2020
through 2025

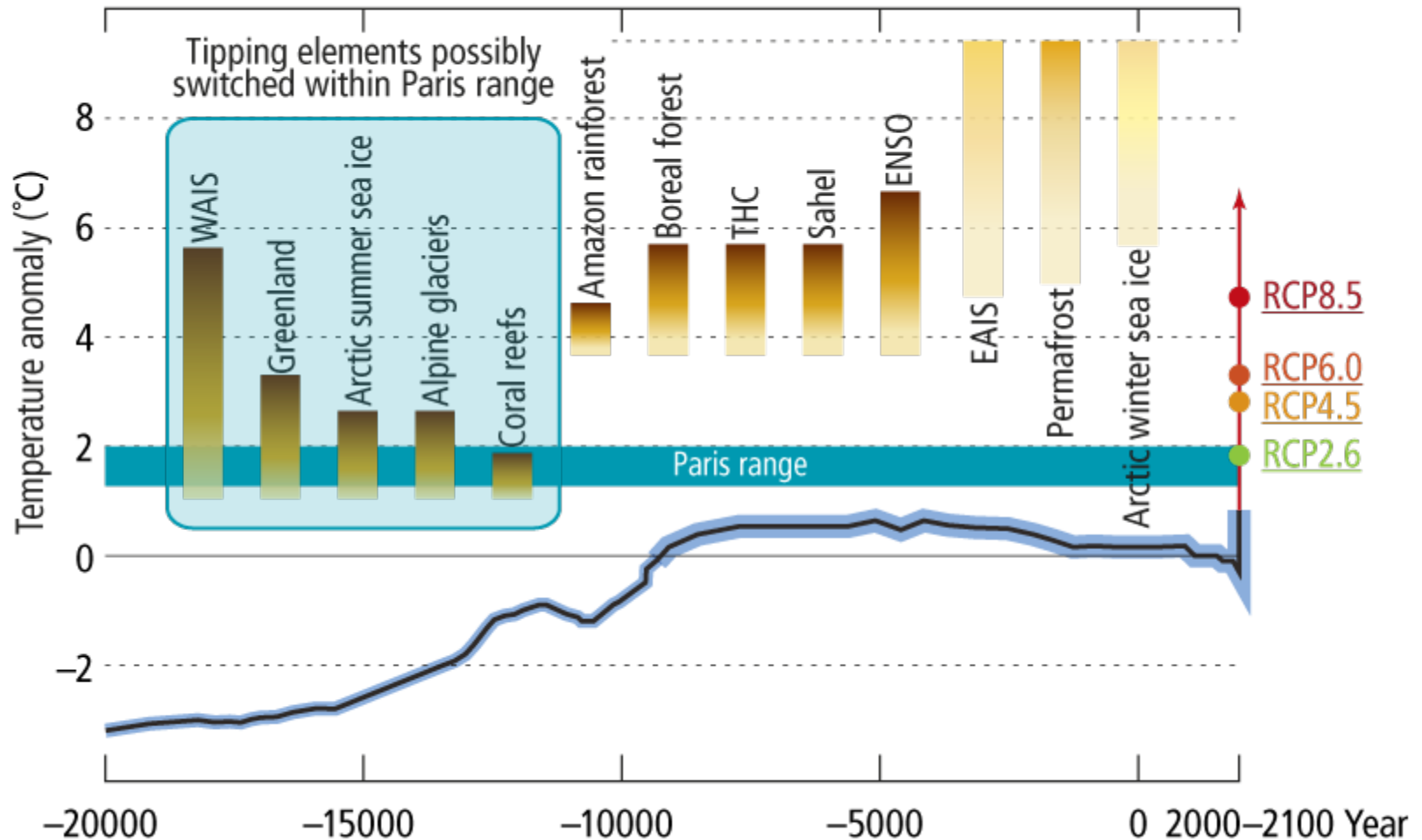
Source: Schellnhuber, 2016

100,000-year ice-core record



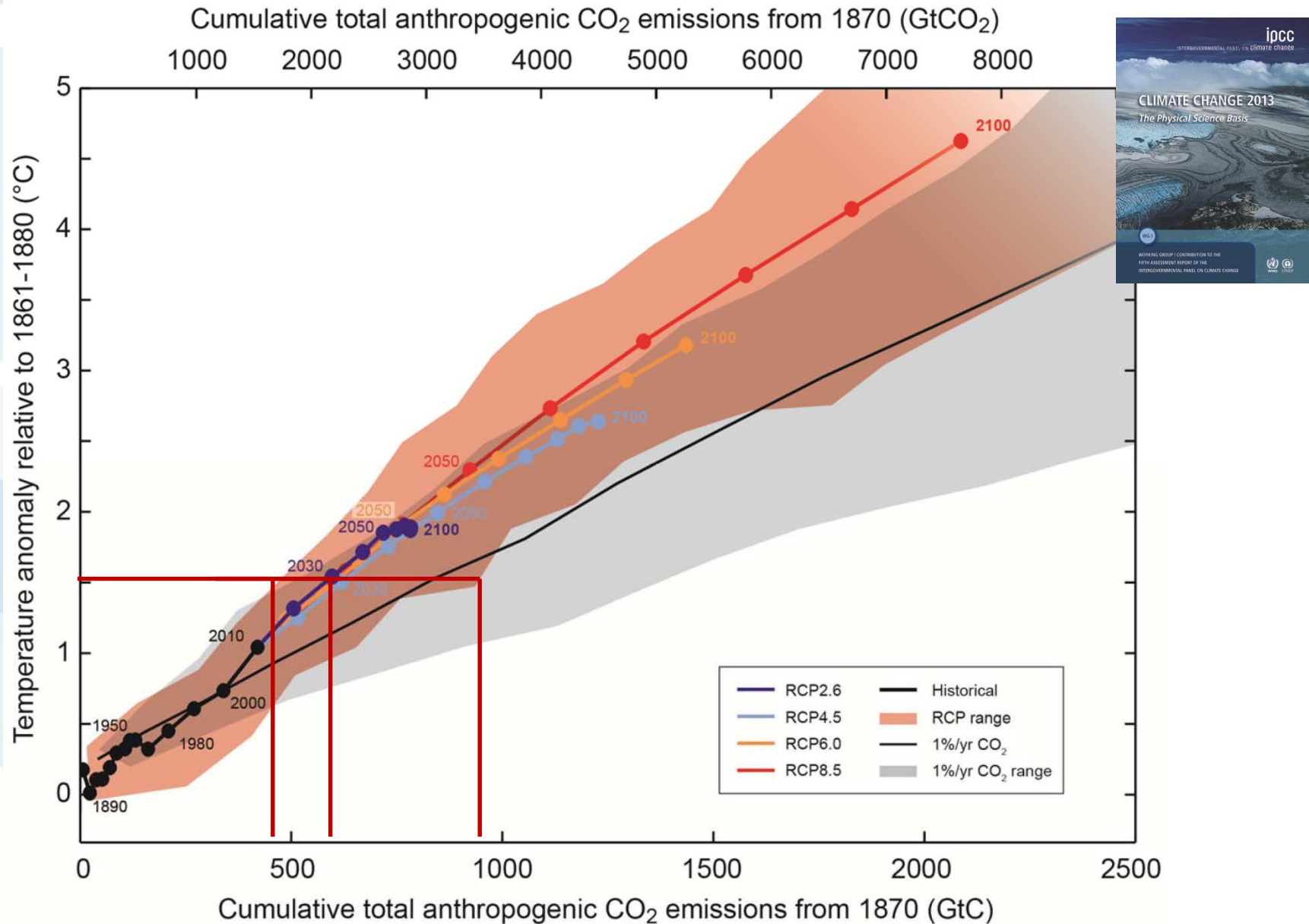
Source: Data from Petit et al. 1999, labeled as in Young and Steffen 2009.

Tipping Elements & Paris



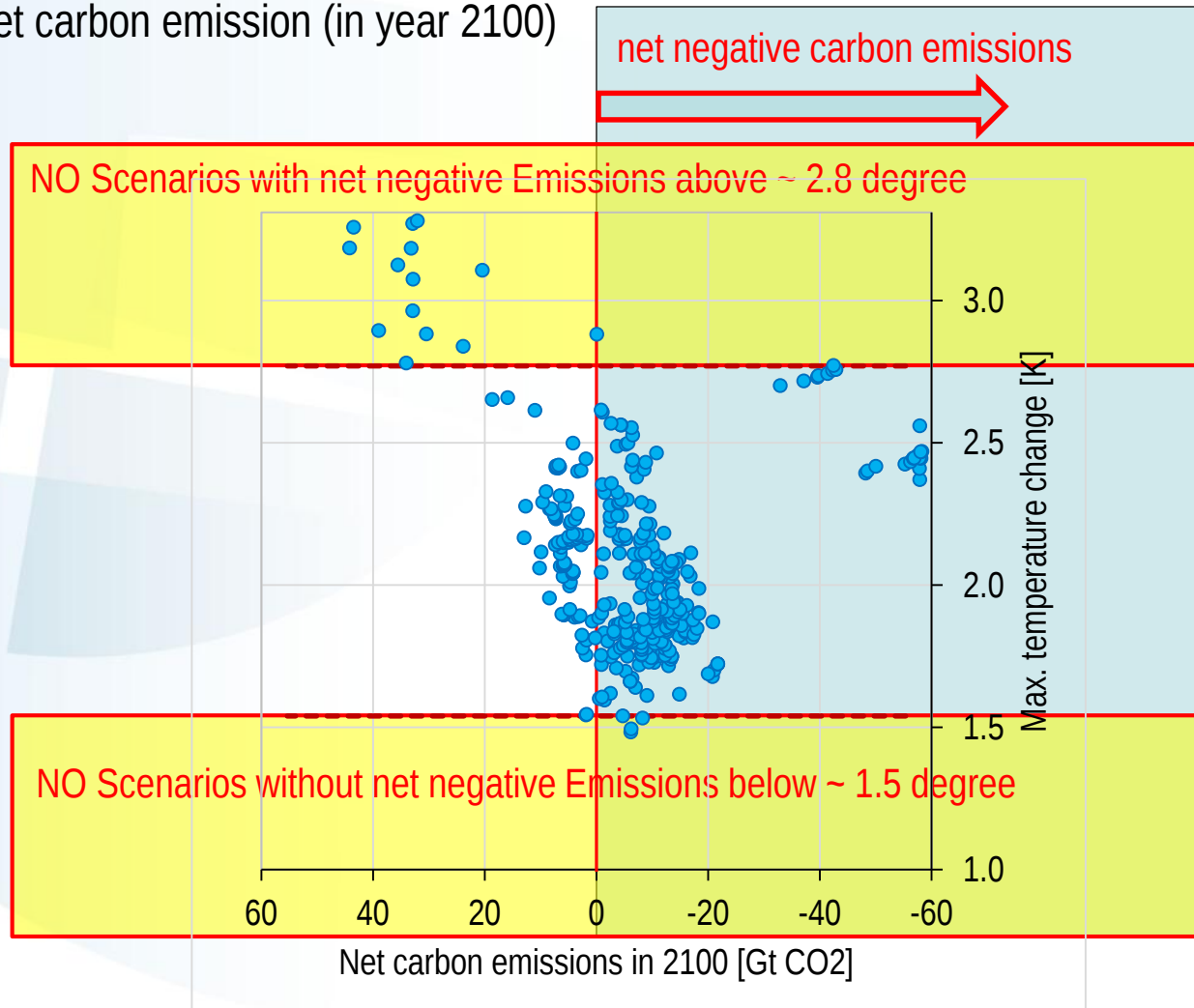
Adapted from Schellnhuber et al. 2016

Cumulative Emissions & Temperature

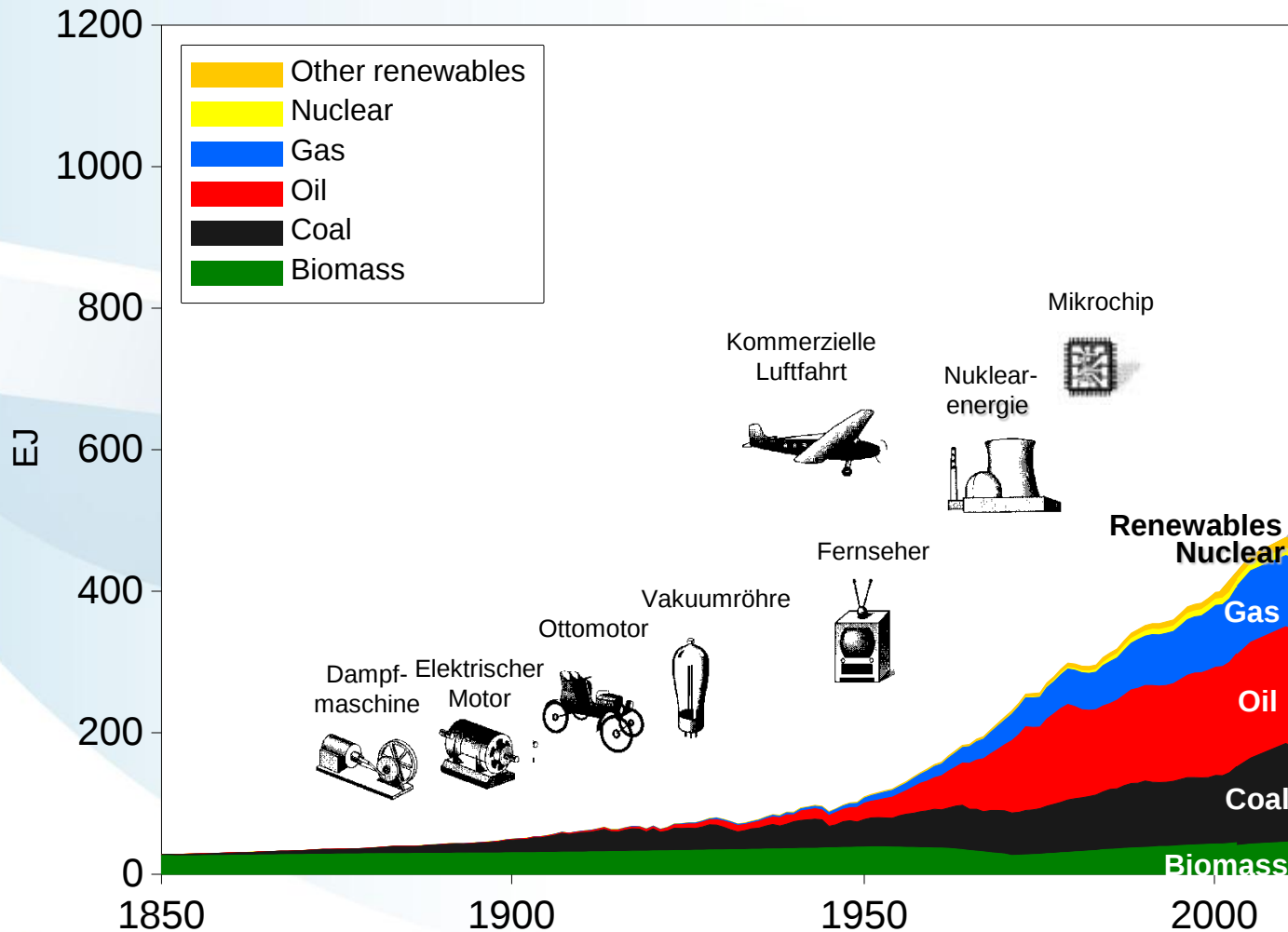
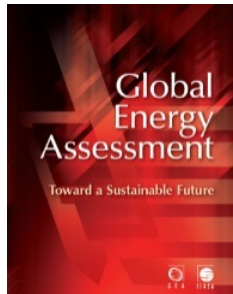


Net-Negative CO₂ Emissions

Max. temperature change in 21th century
Net carbon emission (in year 2100)

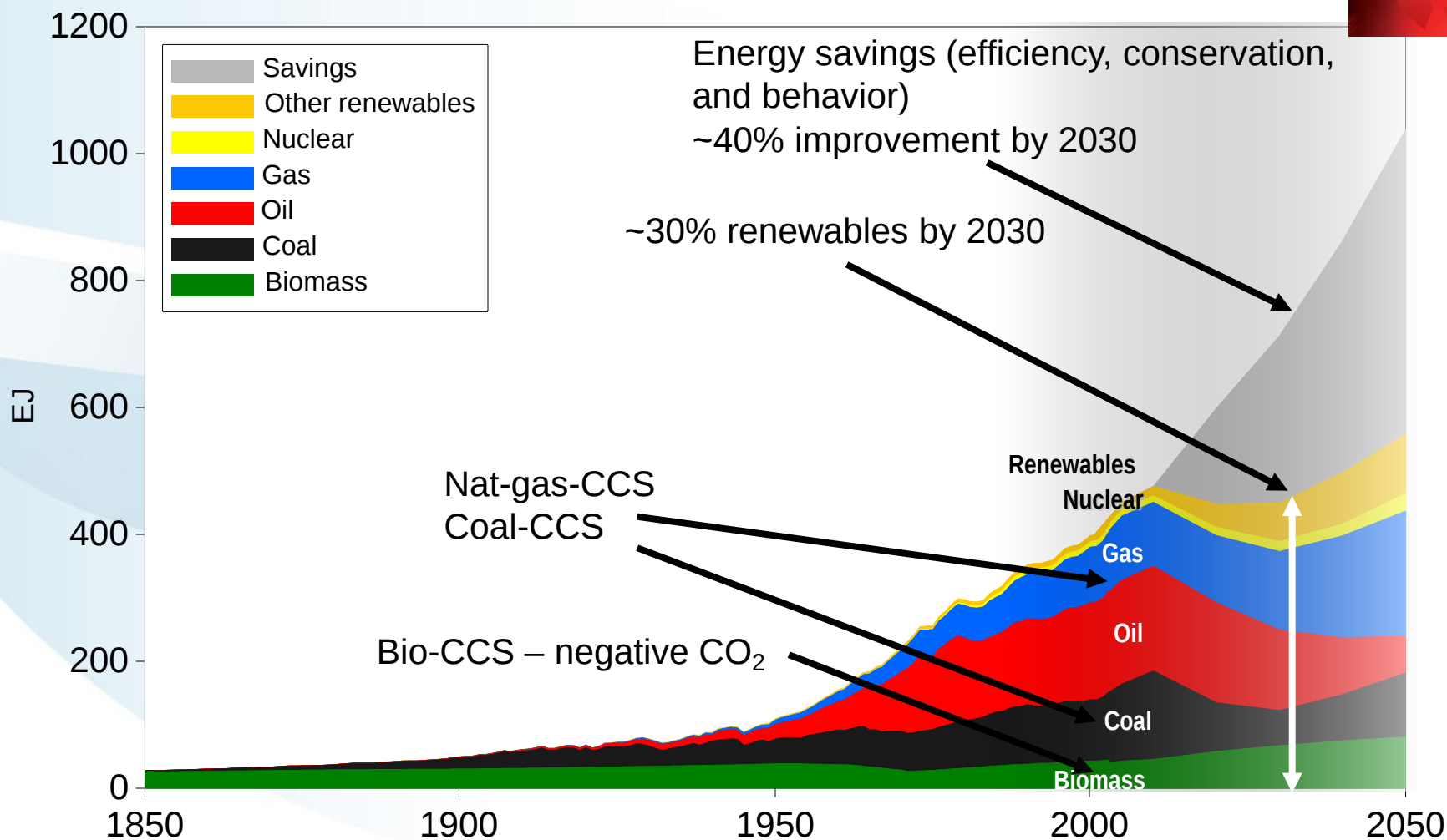
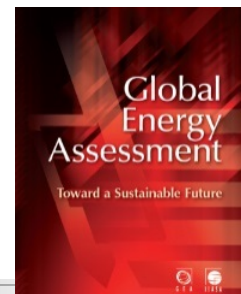


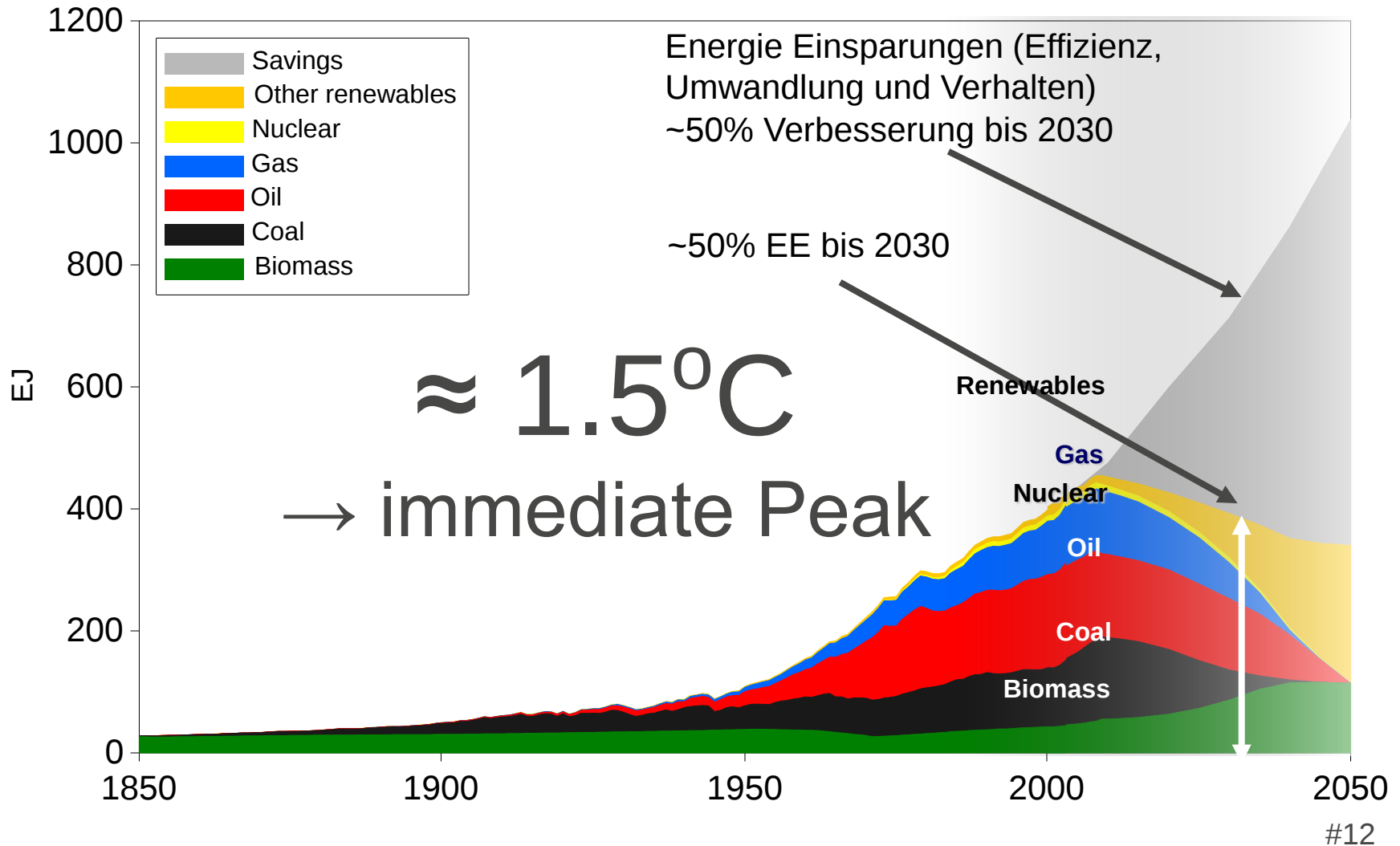
Global Primary Energy Historical Evolution



Global Primary Energy

A Transformational Pathway







lumpy
large unit size
high unit cost
indivisible



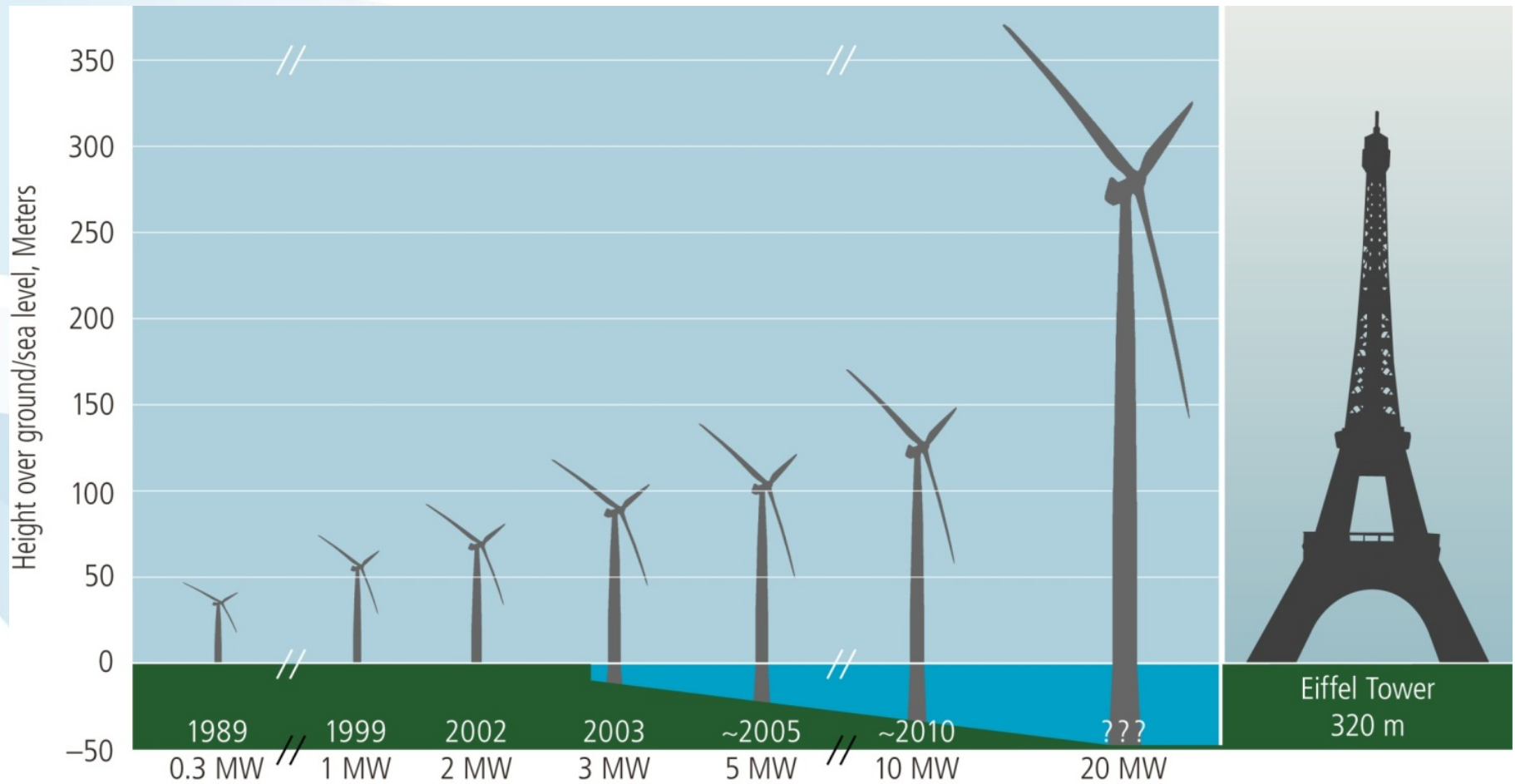
**Granularity:
Technology
Unit
Scales**



granular
small unit size
low unit cost
modular



“Learning” Through Scale



Economies of scale, US wind turbines

Possible transformational technologies

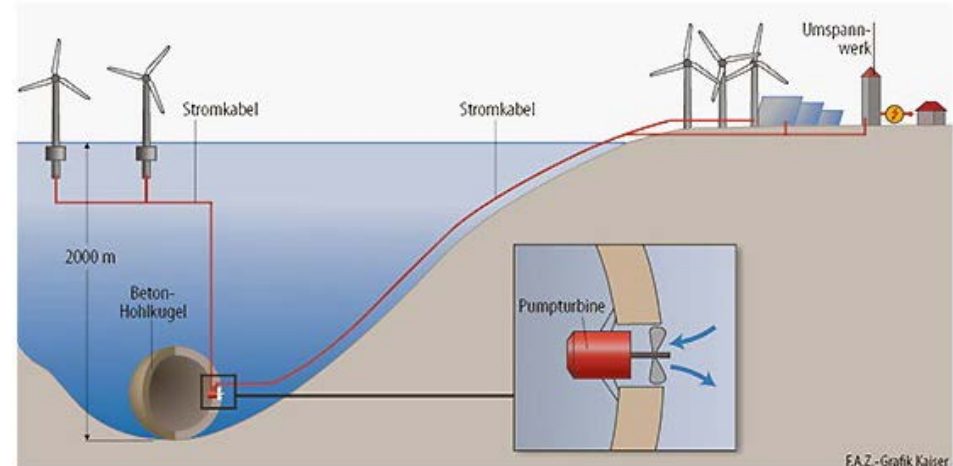
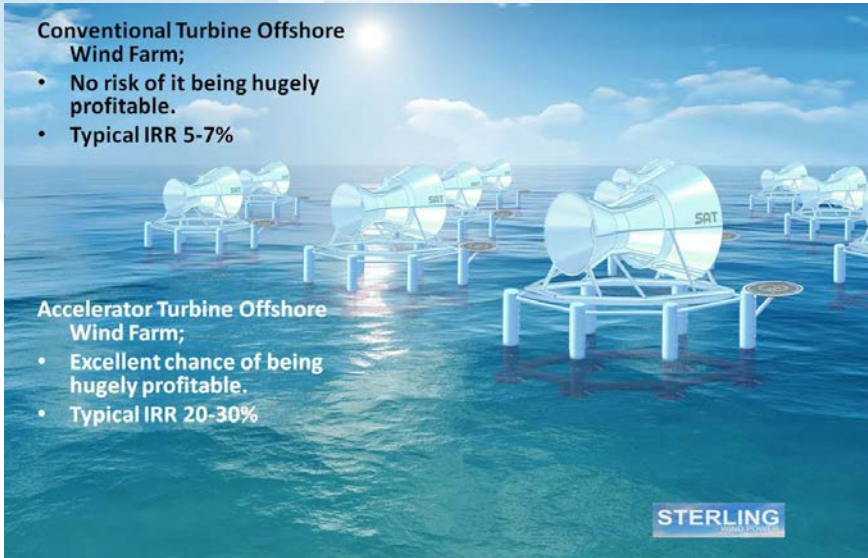


Conventional Turbine Offshore Wind Farm;

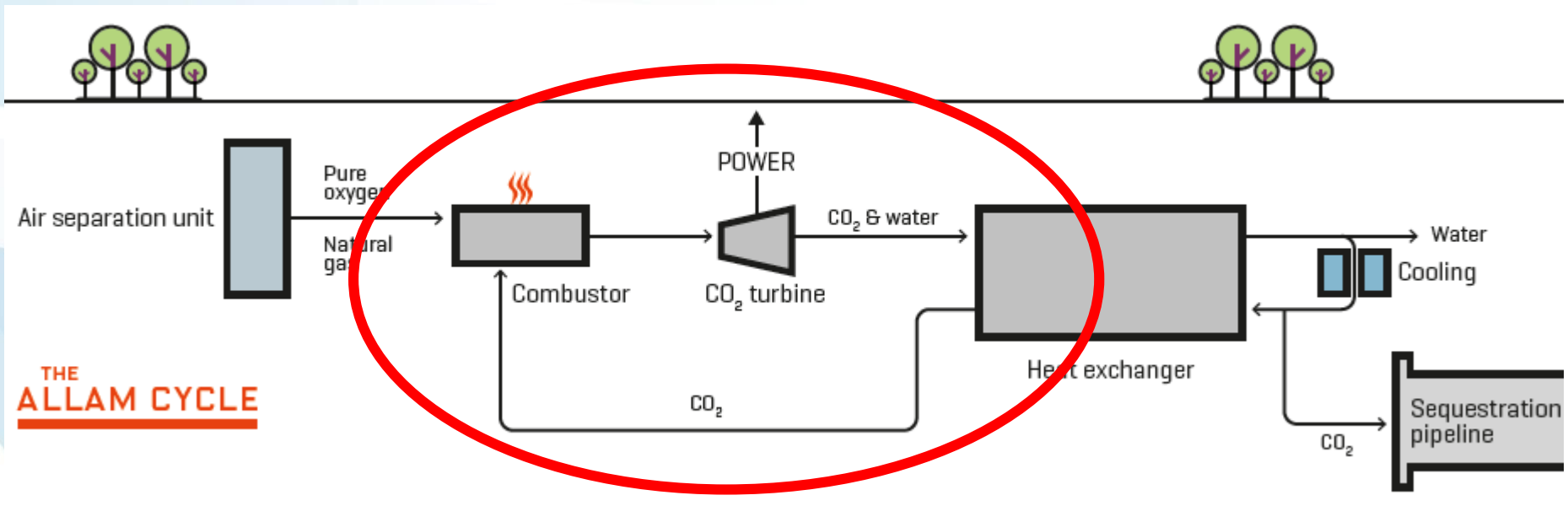
- No risk of it being hugely profitable.
- Typical IRR 5-7%

Accelerator Turbine Offshore Wind Farm;

- Excellent chance of being hugely profitable.
- Typical IRR 20-30%

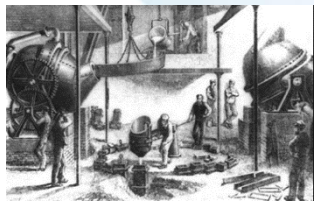
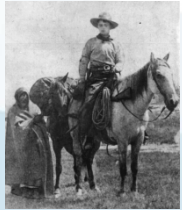
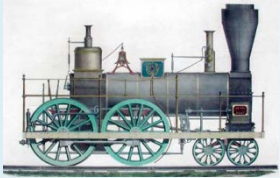


Breaks Ground on Demonstration Plant for Oxyfuel, Nantural Gas ZEP, La Porte, Texas

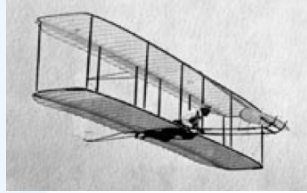
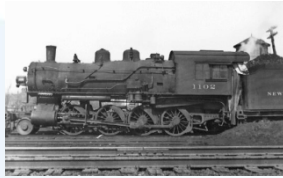


Transformational Change

1850



1900



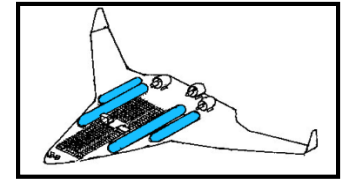
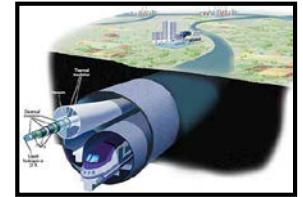
1950



2000



2050



Source: After Granger Morgan, 2013

2017 #17

Disruptive Change

Easter Parade on Fifth Avenue, New York, 13 years apart

1900: where's the car?

1913: where's the horse?



Images: L, National Archive, www.archives.gov/research/american-cities/images/american-cities-101.jpg
R, shorpy.com/node/204.

Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica CA, 28 Oct 2014,
<http://tonaseba.com/keynote-at-altcar-2014-100-electric-transportation-100-solar-by-2030/>

THANK YOU

science for global insight



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