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Applied Systems Analysis  
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science for global insight



# Grand Transformation toward Sustainable Future for All

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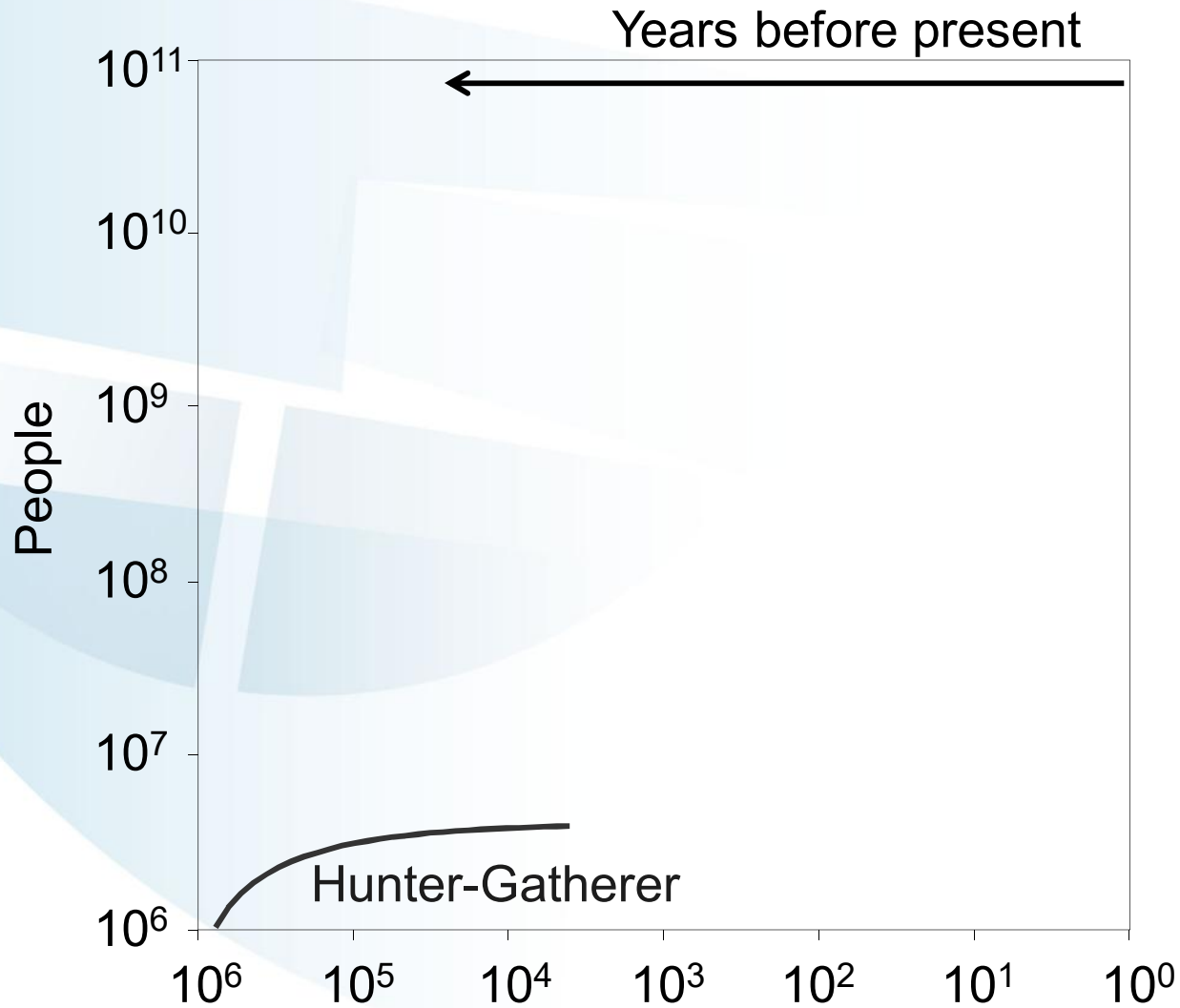
Vienna University of Technology

*ALPS International Symposium, RITE, Tokyo – 7 February 2017*



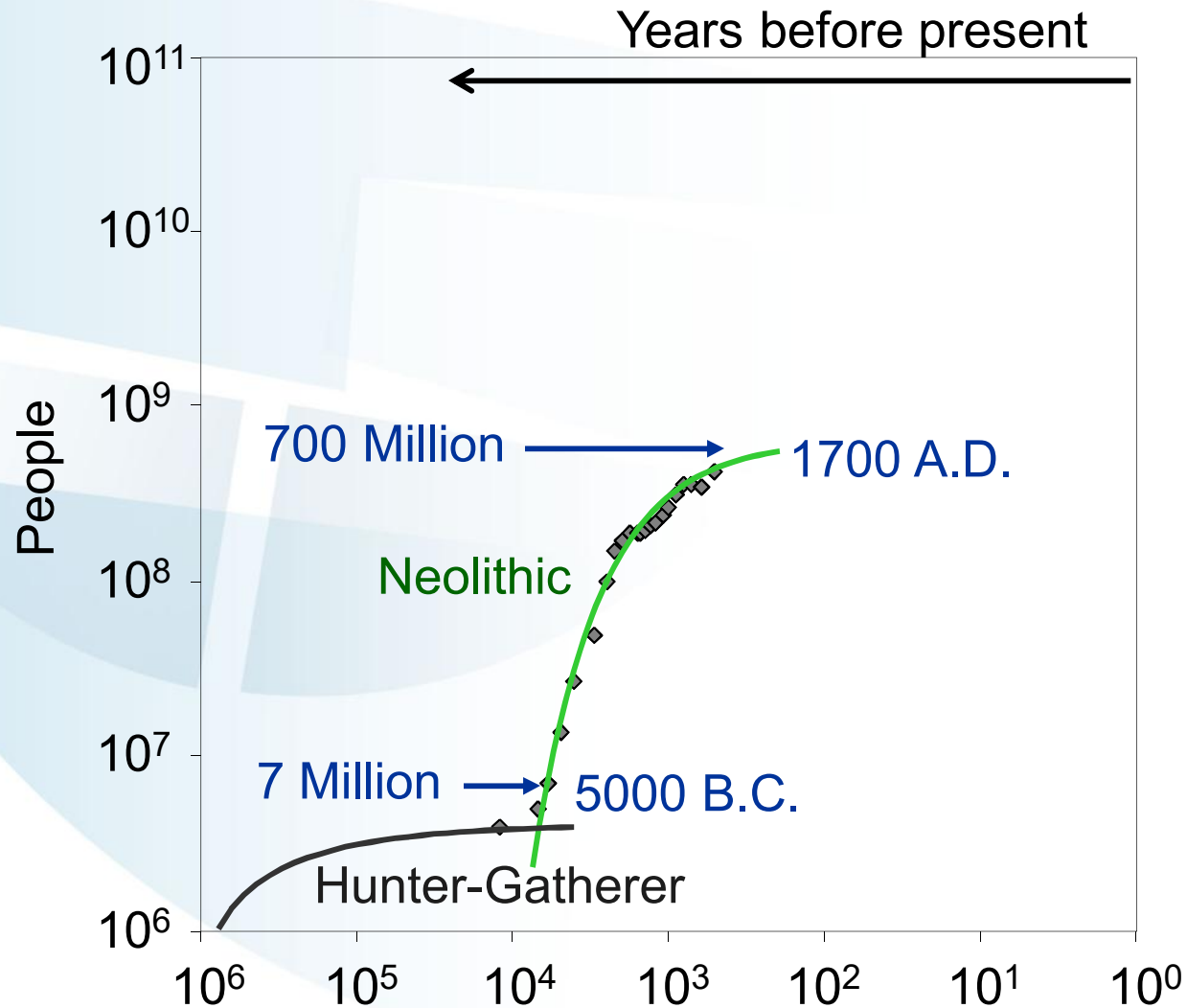
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# Global Transformations



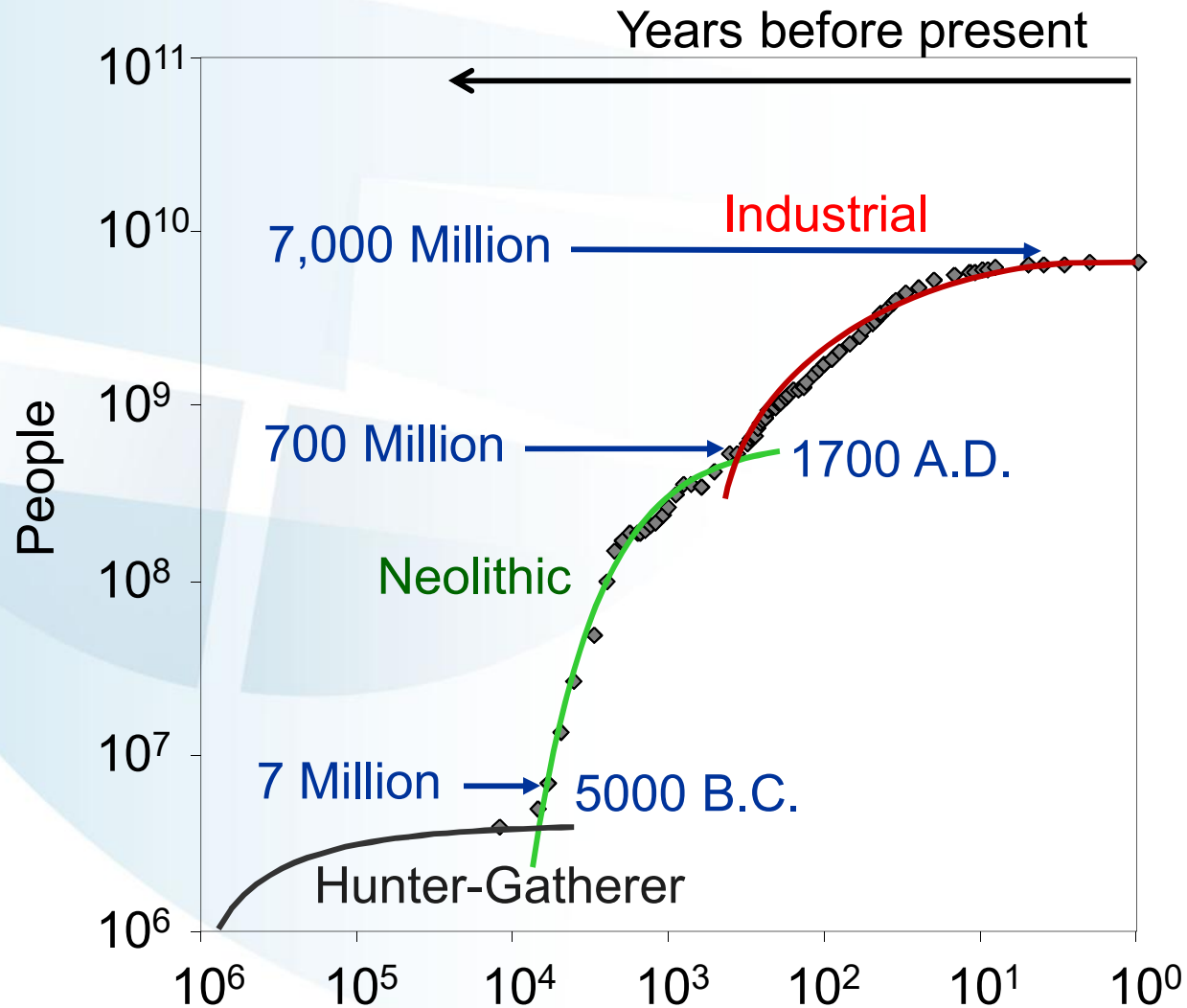
# Global Transformations

## Neolithic Revolution



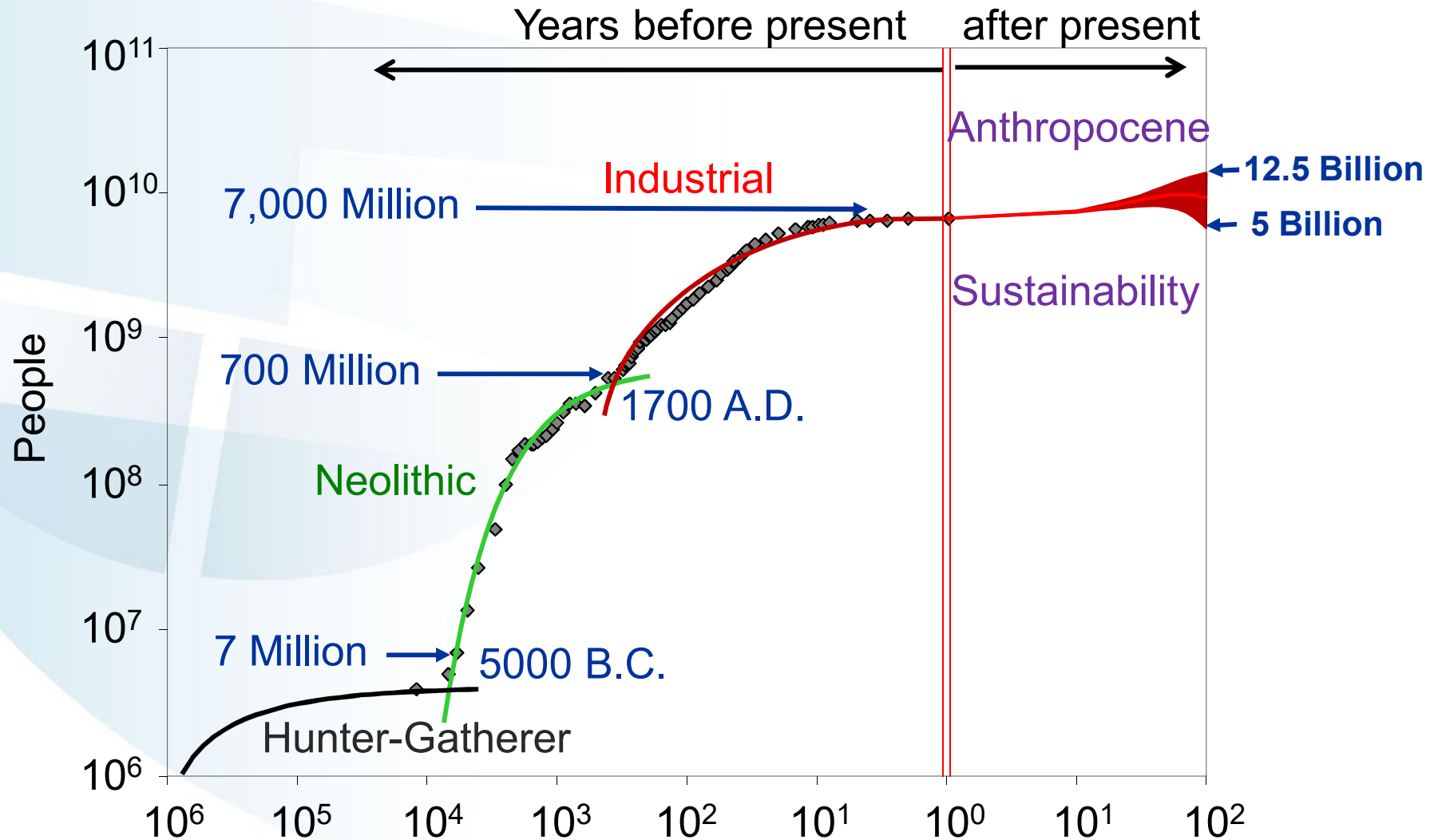
# Global Transformations

## Neolithic and Industrial Revolutions



# Global Transformations

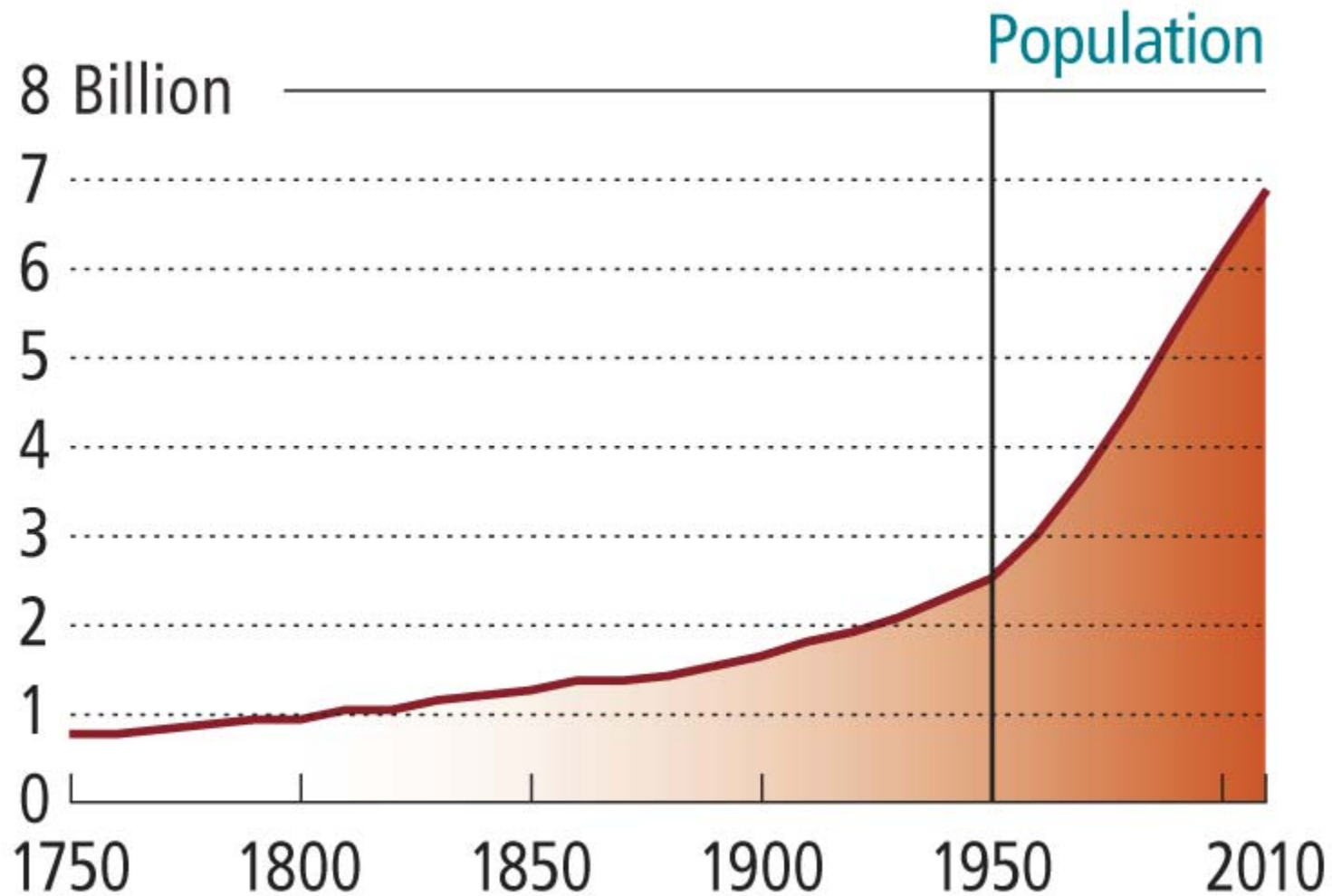
## Anthropocene - Toward Sustainability



# Stockton – Darlington Steam Railway



# The Great Acceleration



Source: Steffen et al. 2015



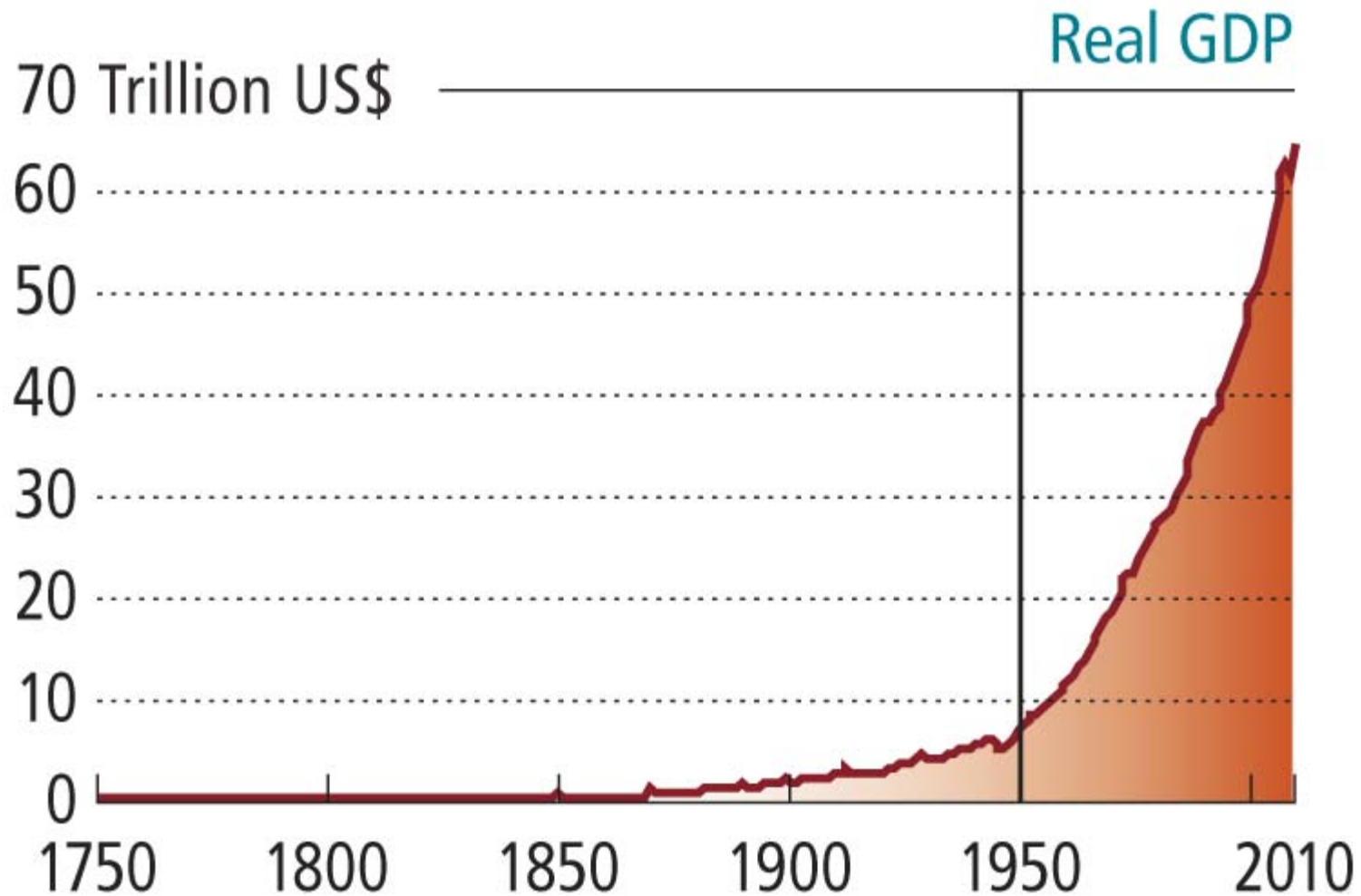
Nakicenovic



Rockström

IUCN, 2017 #7

# The Great Acceleration

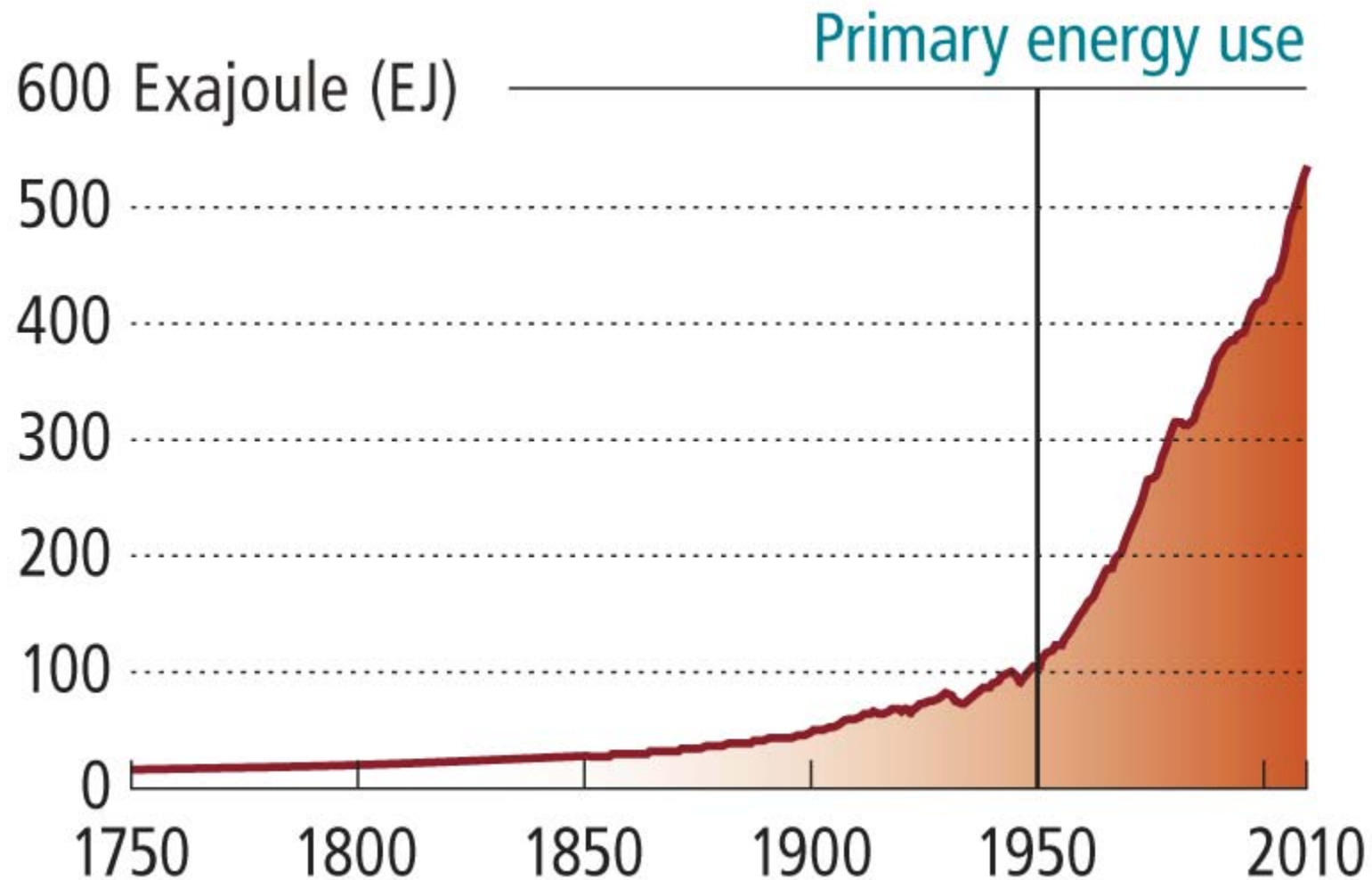


Source: Steffen et al. 2015





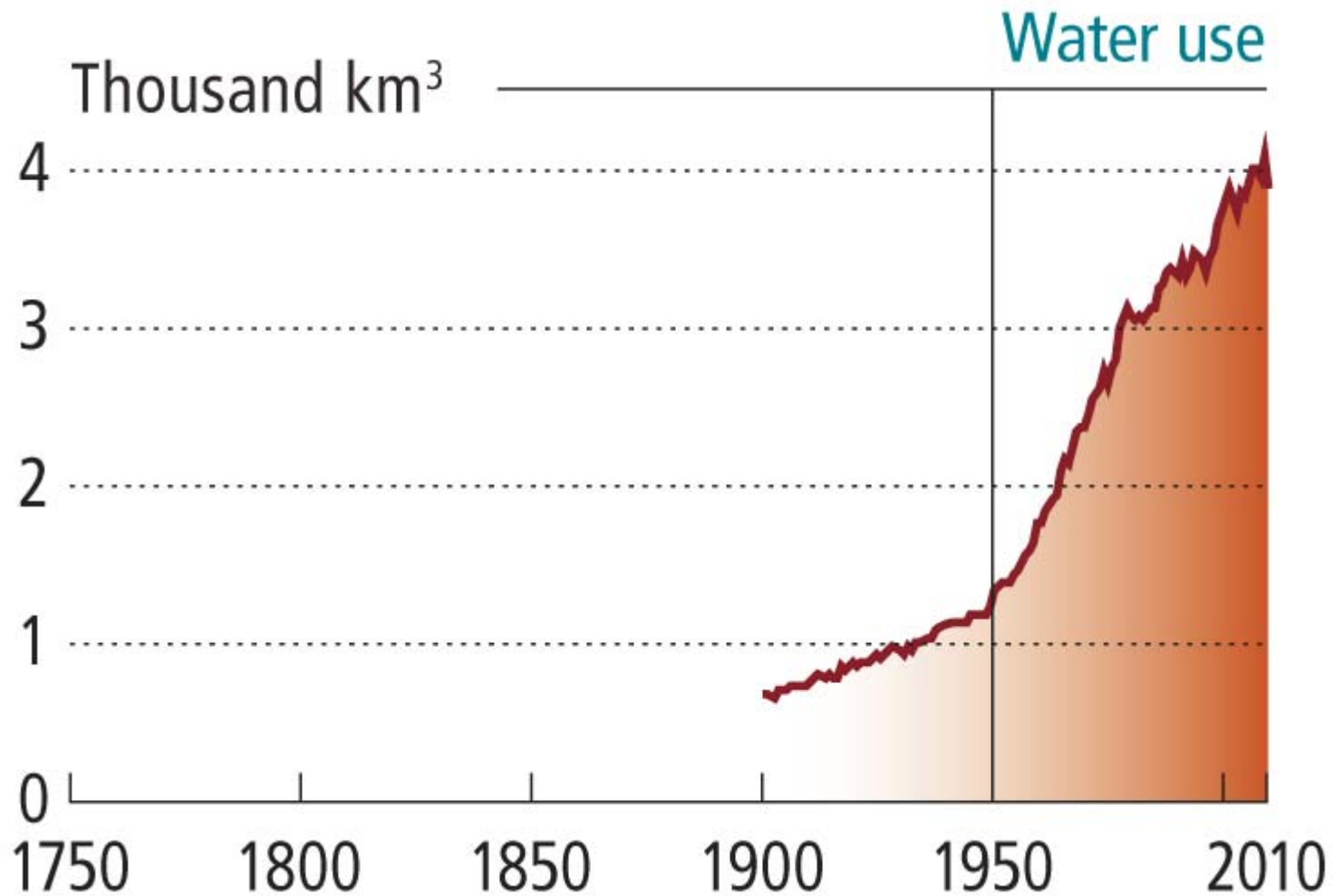
# The Great Acceleration



Source: Steffen et al. 2015



# The Great Acceleration



Source: Steffen et al. 2015



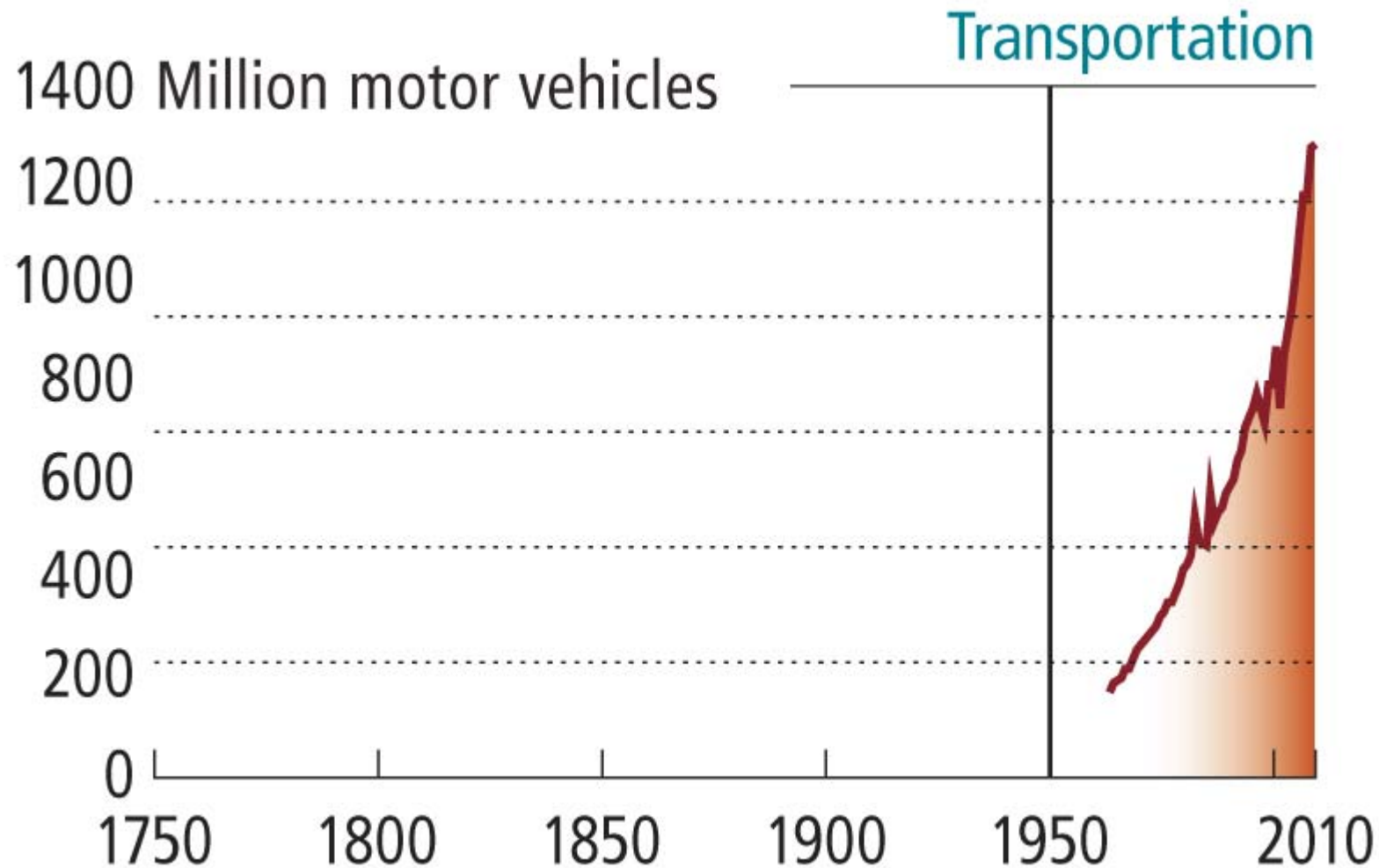
Nakicenovic



Rockström

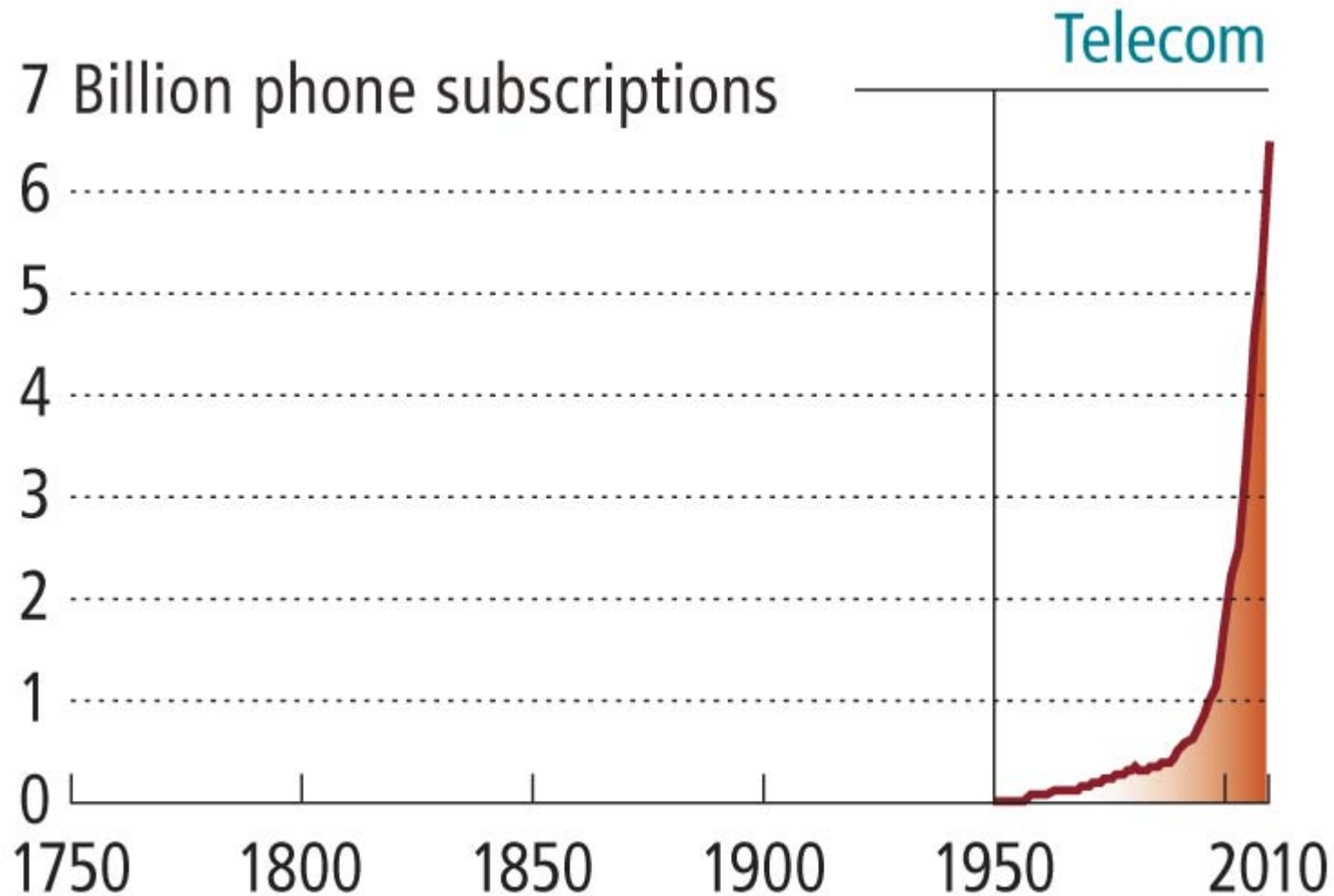
IUCN, 2017 #10

# The Great Acceleration



Source: Steffen et al. 2015

# The Great Acceleration



Source: Steffen et al. 2015



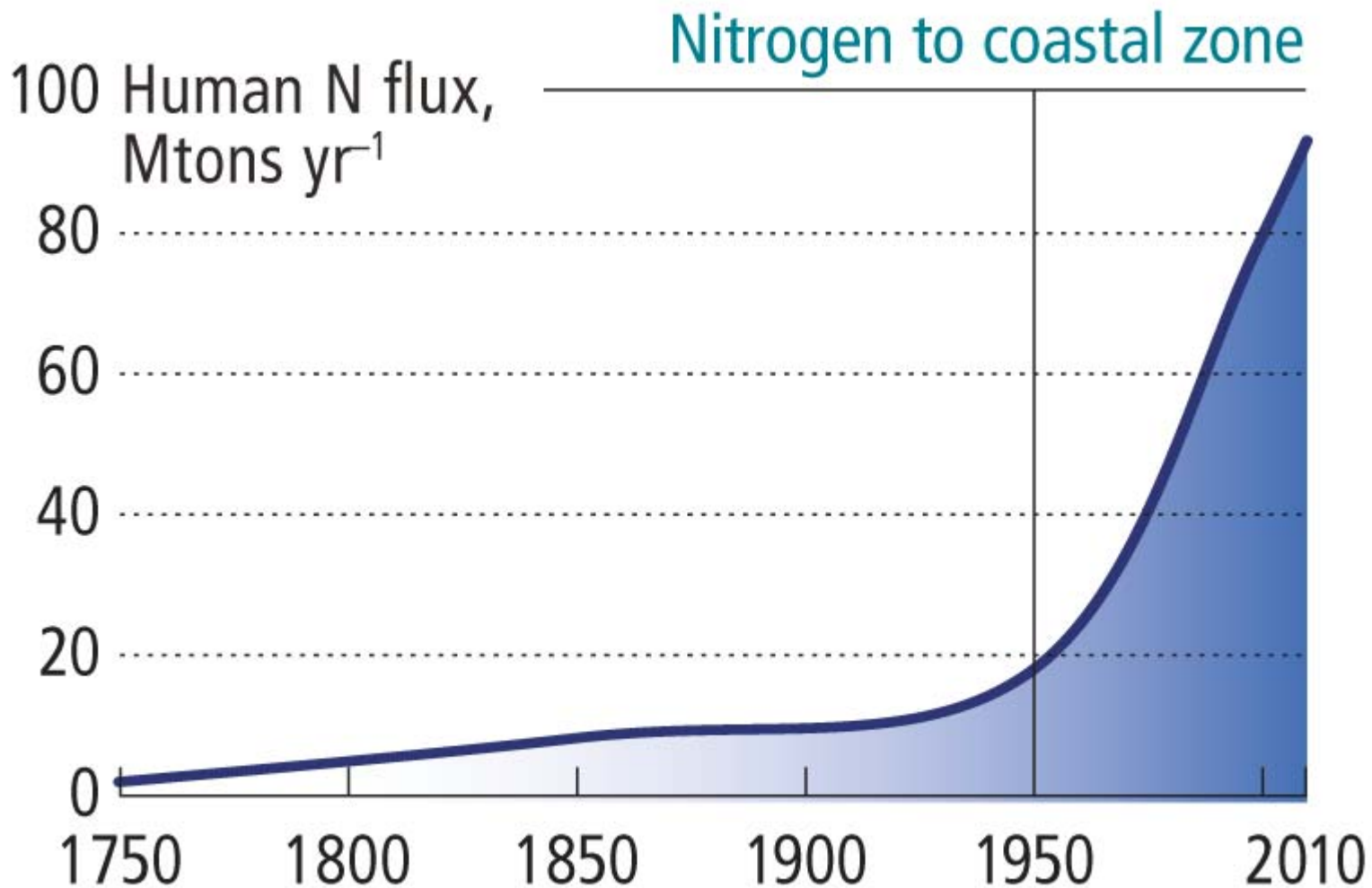
Nakicenovic



Rockström

IUCN, 2017 #12

# The Great Acceleration



Source: Steffen et al. 2015



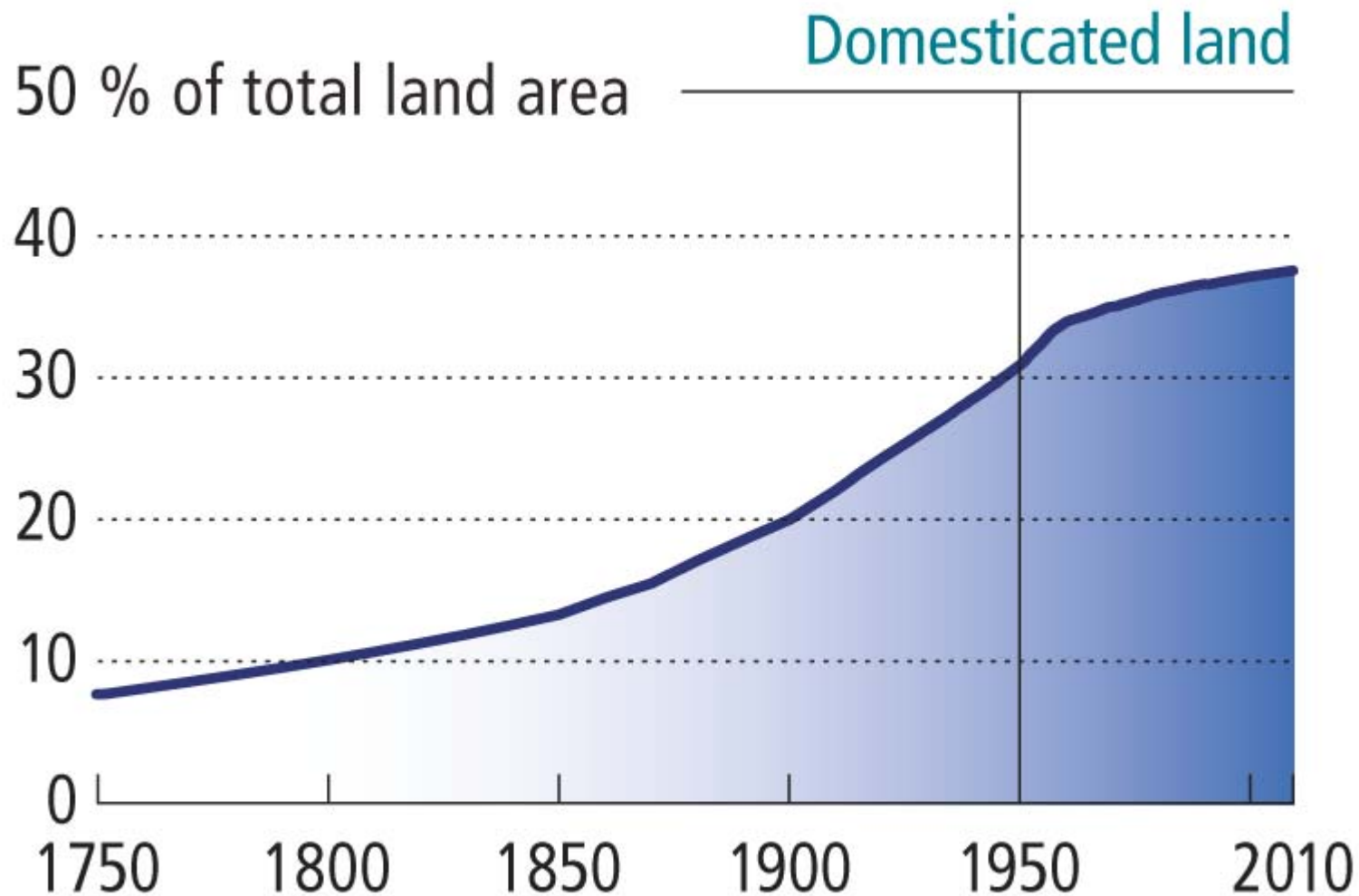
Nakicenovic



Rockström

IUCN, 2017 #13

# The Great Acceleration



Source: Steffen et al. 2015



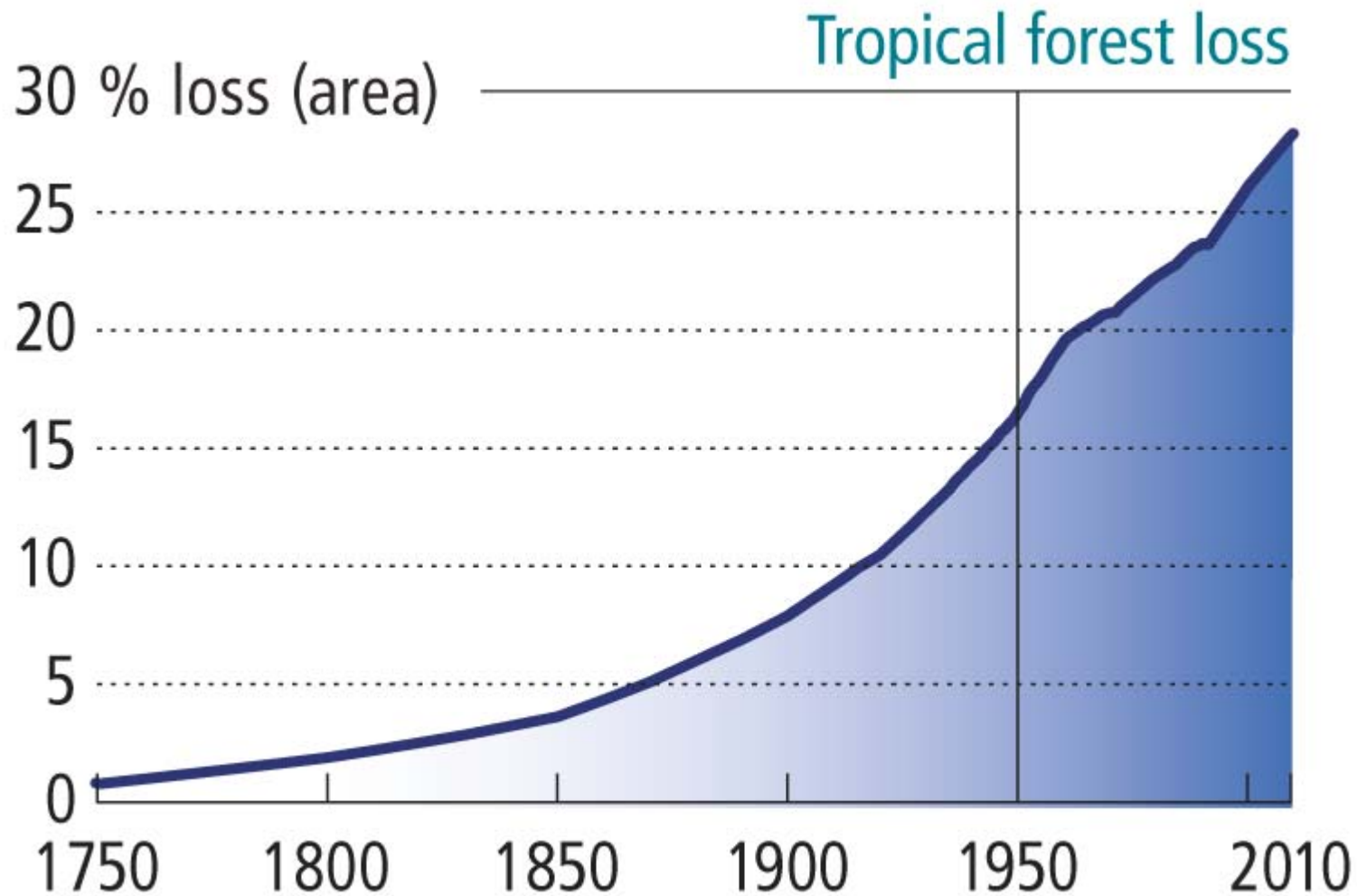
Nakicenovic



Rockström

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# The Great Acceleration



Source: Steffen et al. 2015



Nakicenovic

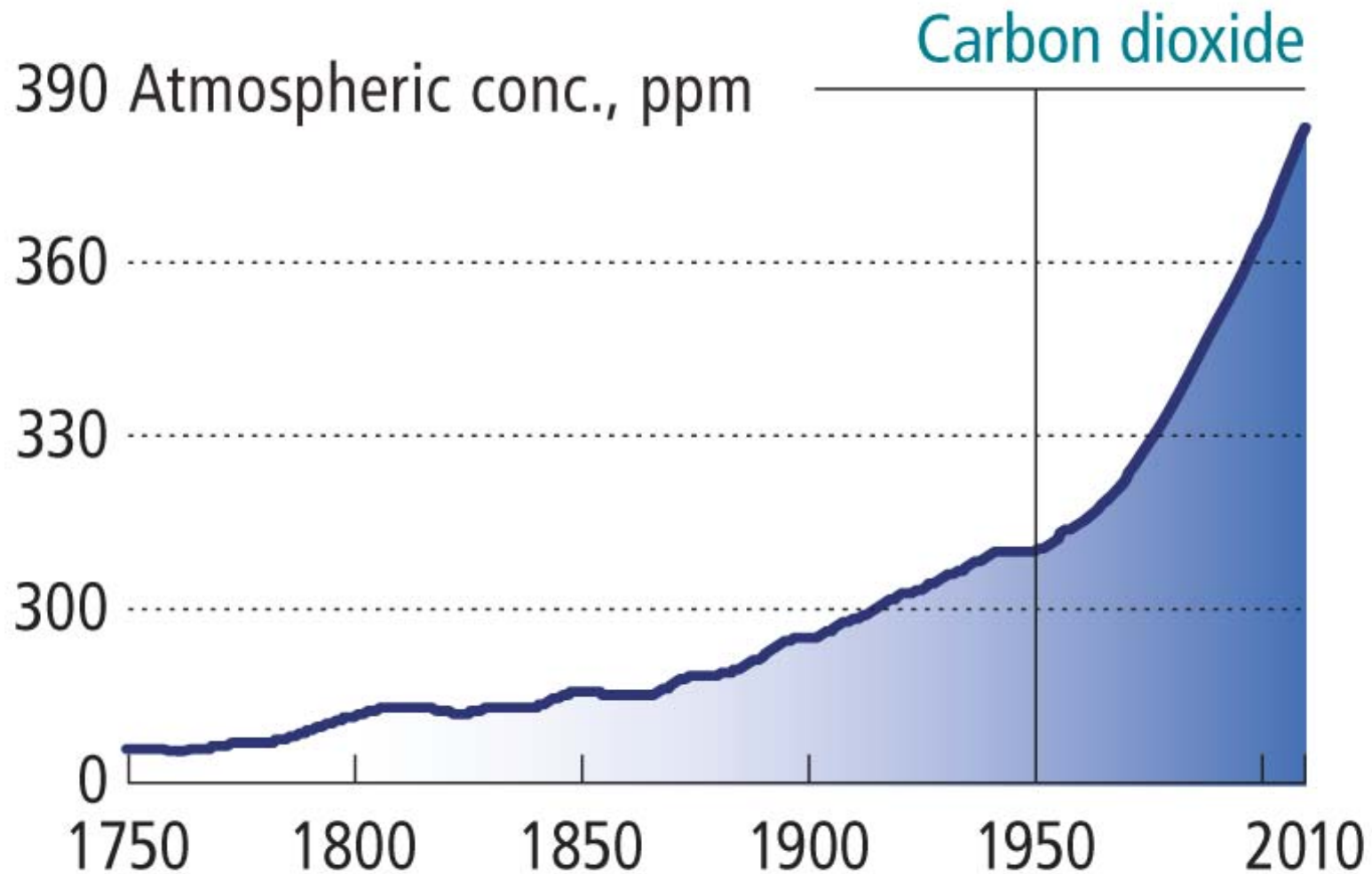


Rockström

IUCN, 2017 #15



# The Great Acceleration



Source: Steffen et al. 2015



Nakicenovic

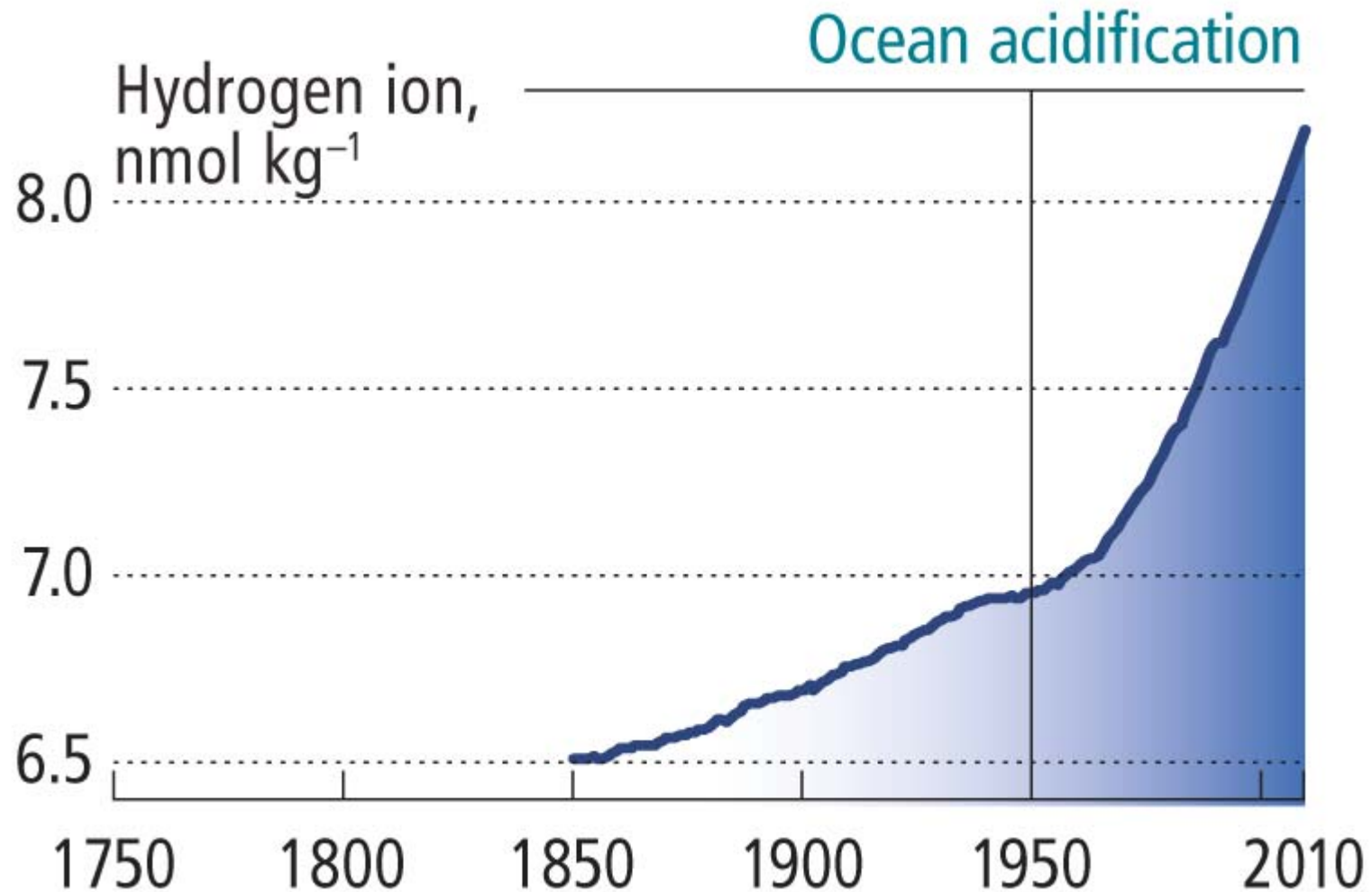


Rockström

IUCN, 2017 #16



# The Great Acceleration



Source: Steffen et al. 2015



Nakicenovic



Rockström

IUCN, 2017 #17

# The Paris Agreement



Bildquelle: <https://www>

Limiting global warming to “well below” 2 degrees celsius

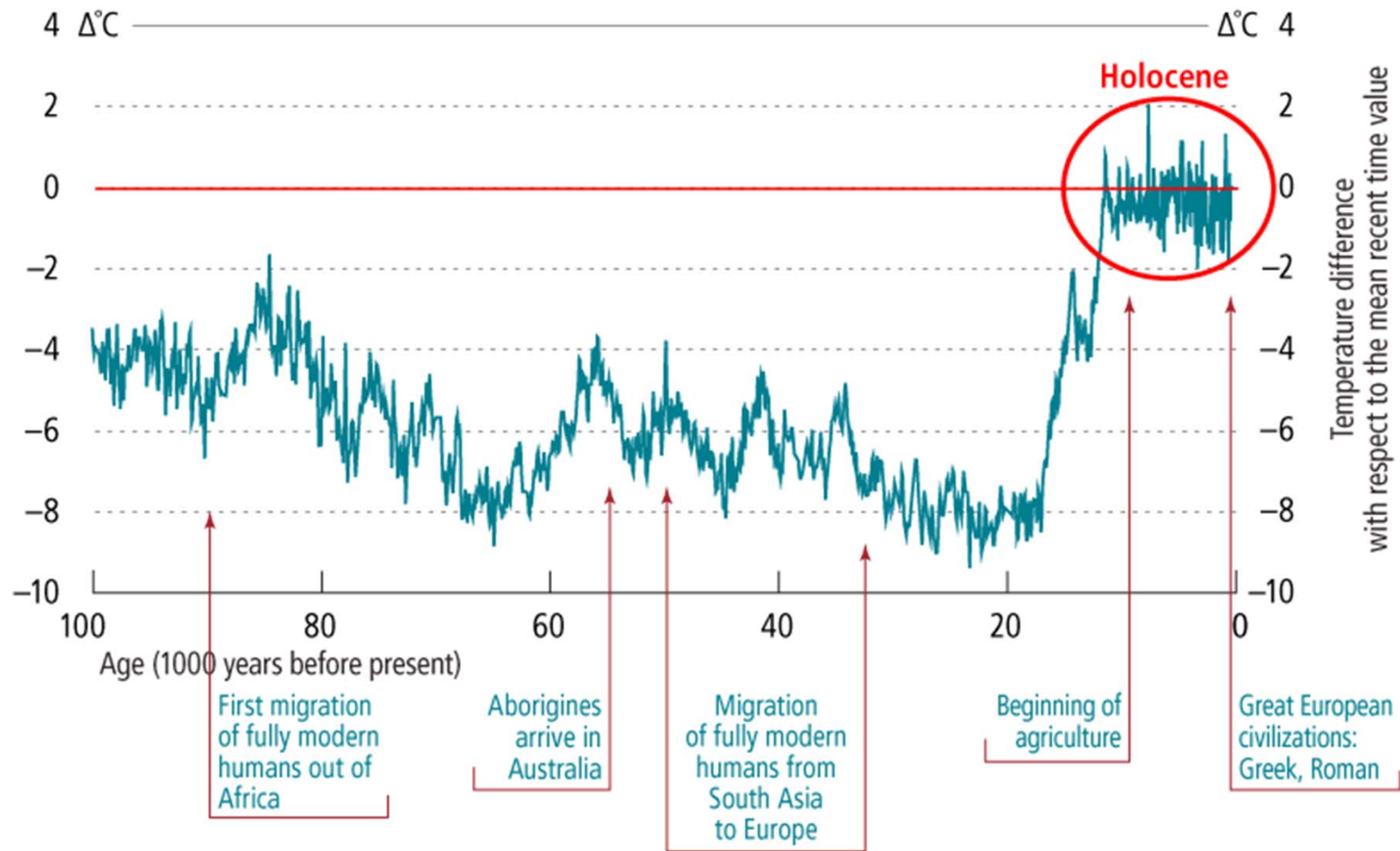
Achieving net-zero GHG emissions by mid of the 21st century

Regular review and improvement of nationally determined contributions

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

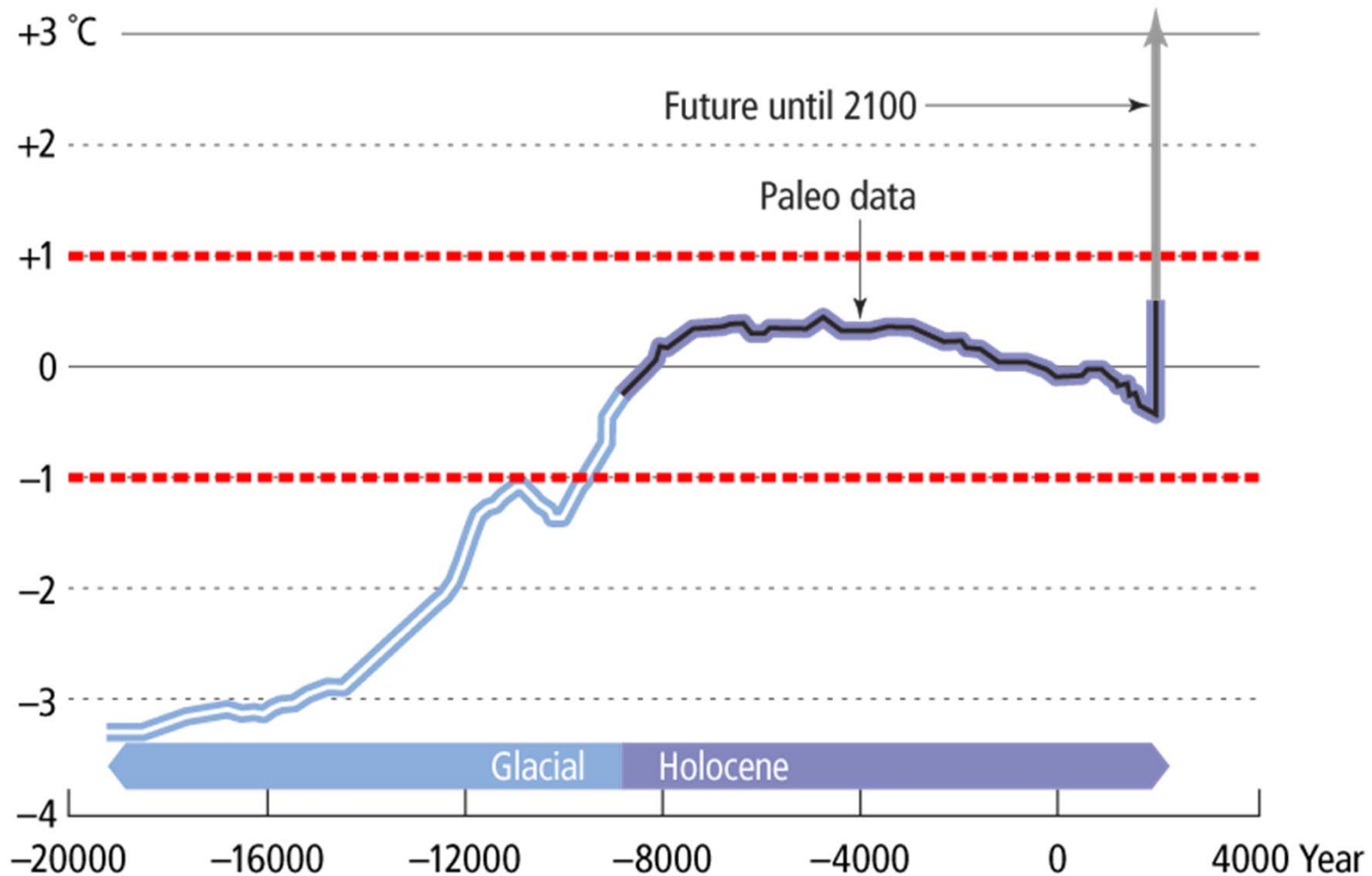
Source: Schellhuber, 2016

# 100,000-year ice-core record



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

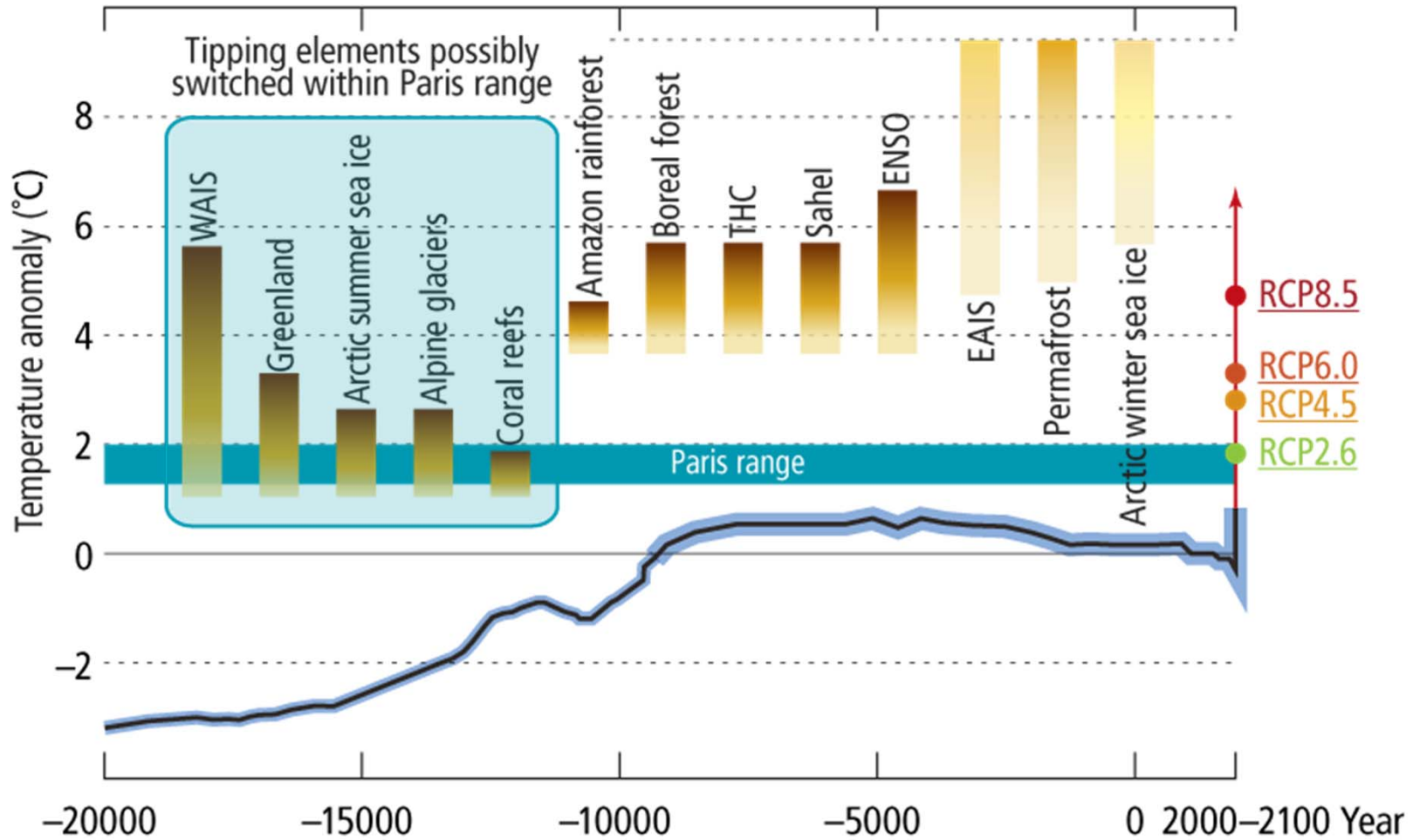
# Holocene Temperature Profile



Adapted from Shakun et al. 2012 and Marcott et al 2013.



# Tipping Elements & Paris



Adapted from Schellnhuber et al. 2016





# The Natomo Family, Kouakourou, Mali



© 2005 PETER MENZEL PHOTOGRAPHY

# The Ukita Family, Tokyo, Japan



© 2005 PETER MENZEL PHOTOGRAPHY







# SUSTAINABLE DEVELOPMENT GOALS



## ➔ Japan – SDG Implementation Guiding Principles & Specific Measures to Achieve SDGs



# Integrated Systems approach to SDG-Pathways

We lack a truly integrated, comprehensive quantitative understanding of sustainable development pathways, accounting for the inter-linkages between the economy, technology, environment, climate, human development and planetary boundaries.

# The World in 2050 (TWI2050.com)

- ➔ How to achieve global development within a safe and just operating space
- ➔ “Safe space” of interaction among SDGs: sustainability narratives and integrated models e.g. SSP1, GEA, DDPP
- ➔ Multiple-benefits and tradeoffs of transformation toward sustainable futures



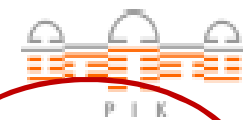
# The World in 2050 (TWI2050.com)





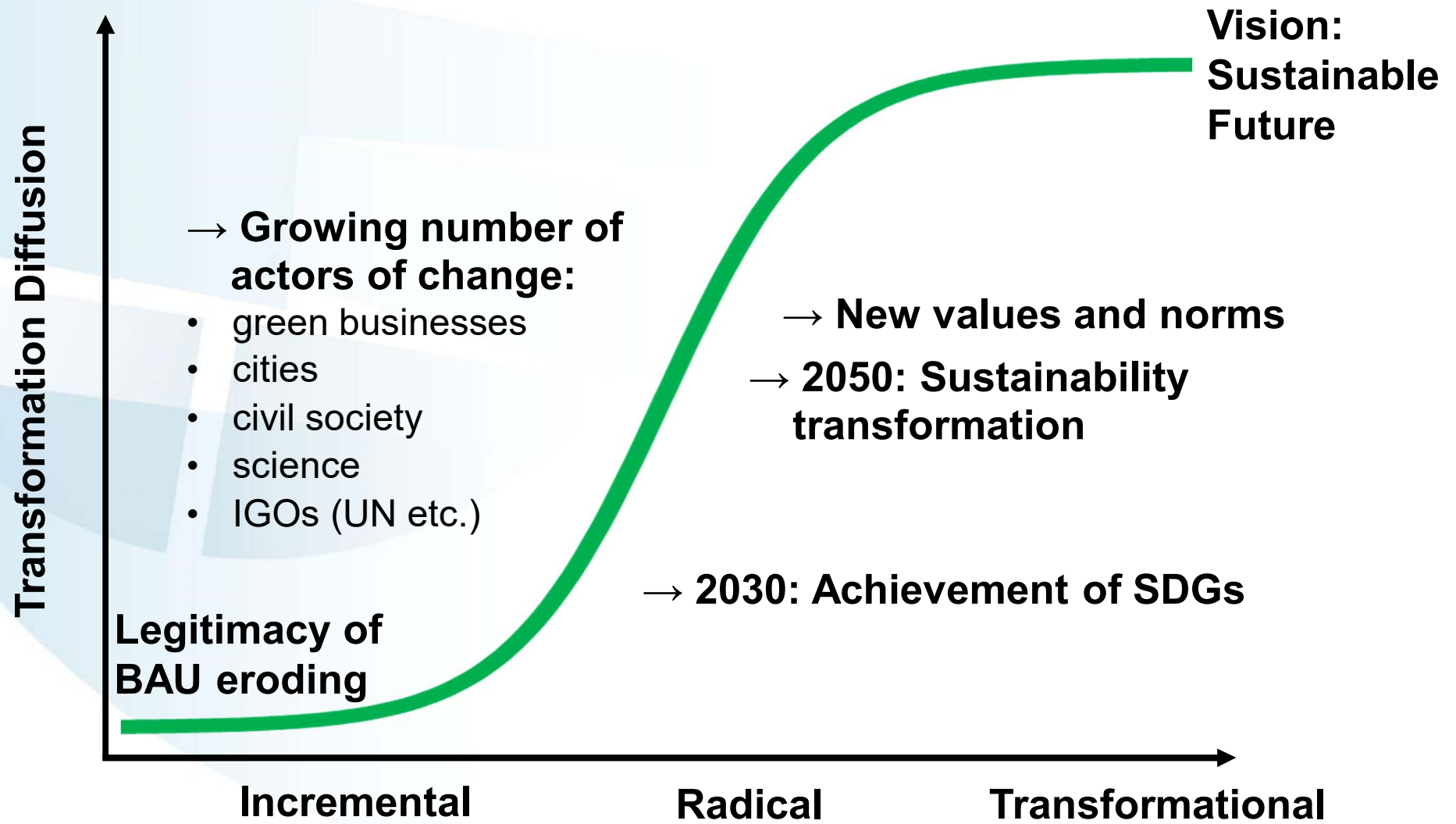
# The World in 2050 “Consortium”

- AIMS
- Brazilian Federal Agency for the Support and Evaluation of Graduate Education (CAPES)
- Centre for Integrated Studies on Climate Change and the Environment (CIRED)
- Commonwealth Scientific and Industrial Research Organization (CSIRO)
- Earth League, whole Earth system modelling initiative
- **Earth Institute, Columbia University**
- Energy Planning Program, COPPE, Federal University of Rio de Janeiro
- Fondazione Eni Enrico Mattei (FEEM)
- Future Earth
- German Development Institute (DIE)
- Global Ocean Ecosystem Dynamics (GLOBEC)
- Indian Institute International Futures
- Indian Institute of Technology (IIT)
- International Energy Agency (IEA)
- International Food Policy Research Institute (IFPRI)
- International Monetary Fund (IMF)
- **International Institute for Applied System Analysis (IIASA)**
- Intergovernmental Panel on Climate Change (IPCC)
- Joint Research Centre, European Commission
- Joint Global Change Research Institute at Pacific Northwest National Laboratory (JGCRI/PNNL)
- Mercator Research Institute on Global Commons and Climate Change
- National Center for Atmospheric Research (NCAR)
- National Institute for Environmental Studies (NIES)
- National Renewable Energy Laboratory (NREL)
- Organisation for Economic Co-operation and Development (OECD)
- Potsdam Institute for Climate Impact Change (PIK)
- PBL - Netherlands Environmental Assessment Agency
- Research Institute of Innovative Technology for the Earth (RITE)
- Stanford University
- **Stockholm Resilience Centre**
- **Sustainable Development Solutions Network (SDSN)**
- The City University of New York (CUNY)
- Tsinghua University
- UN Population Division
- UN DESA
- UNEP- World Conservation Monitoring Centre (UNEP-WCMC)
- University of Hamburg
- World Bank



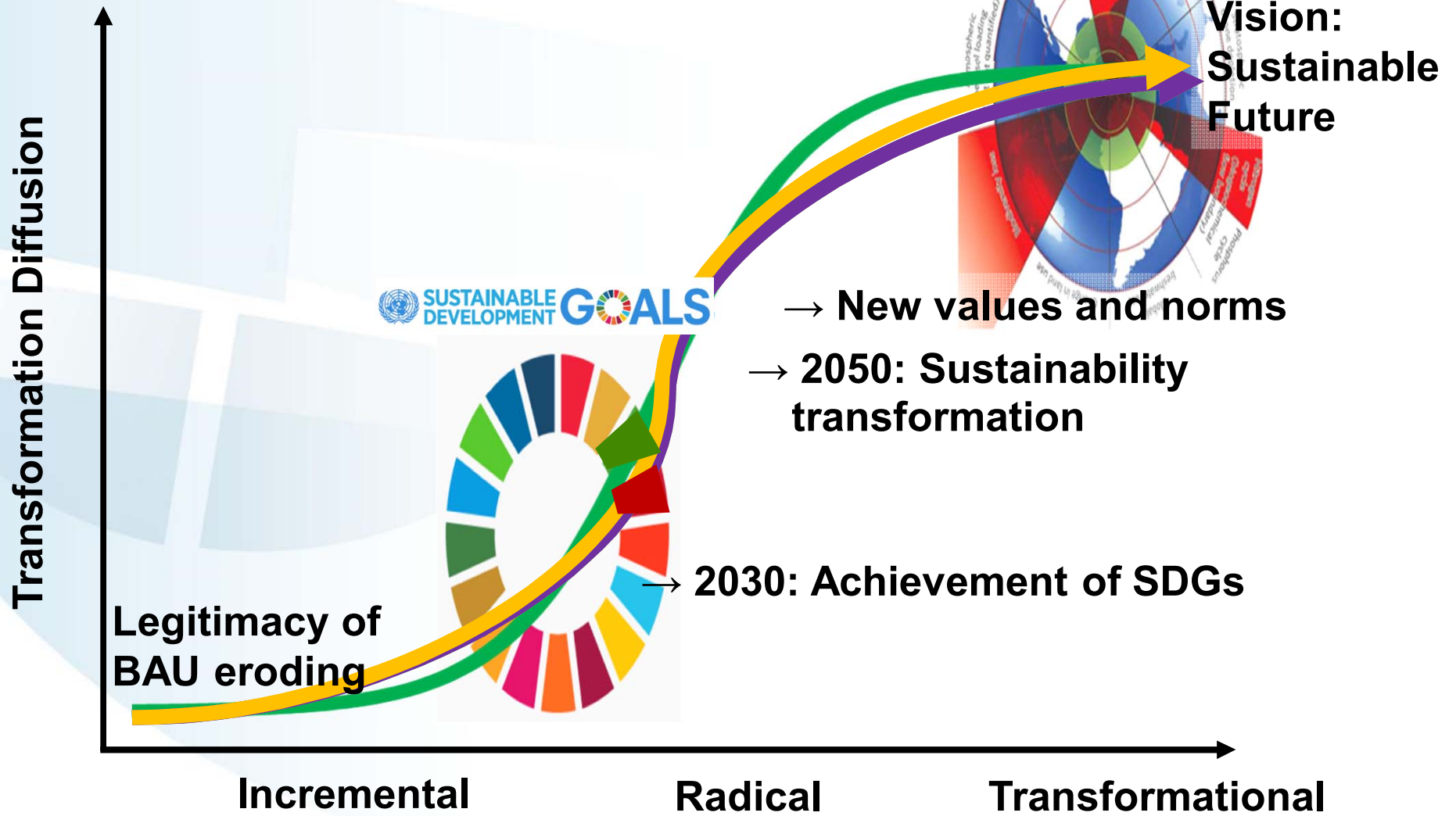
# The World in 2050 (TWI2050.com)

“Doing More with Less” within Planetary Boundaries



# The World in 2050 (TWI2050.com)

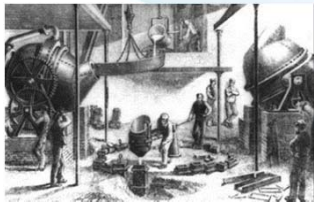
“Doing More with Less” within Planetary Boundaries





# Transformational Change

1850



1900



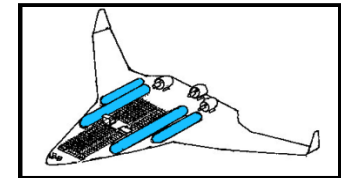
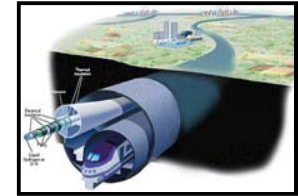
1950



2000



2050



Source: After Granger Morgan, 2013

2017 #32



# Technological Change

## Dynamic, Cumulative, Systemic and Uncertain

- ➔ Incremental – gradual (continuous) and cumulative improvements
- ➔ Abrupt – radical, discontinuous and disruptive as “gales of creative destruction”
- ➔ Add as many mail-coaches as you please, you will never get a railroad by so doing. [Schumpeter, 1935/1951, 136]

# Disruptive Change

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

1900: where's the car?

1913: where's the horse?

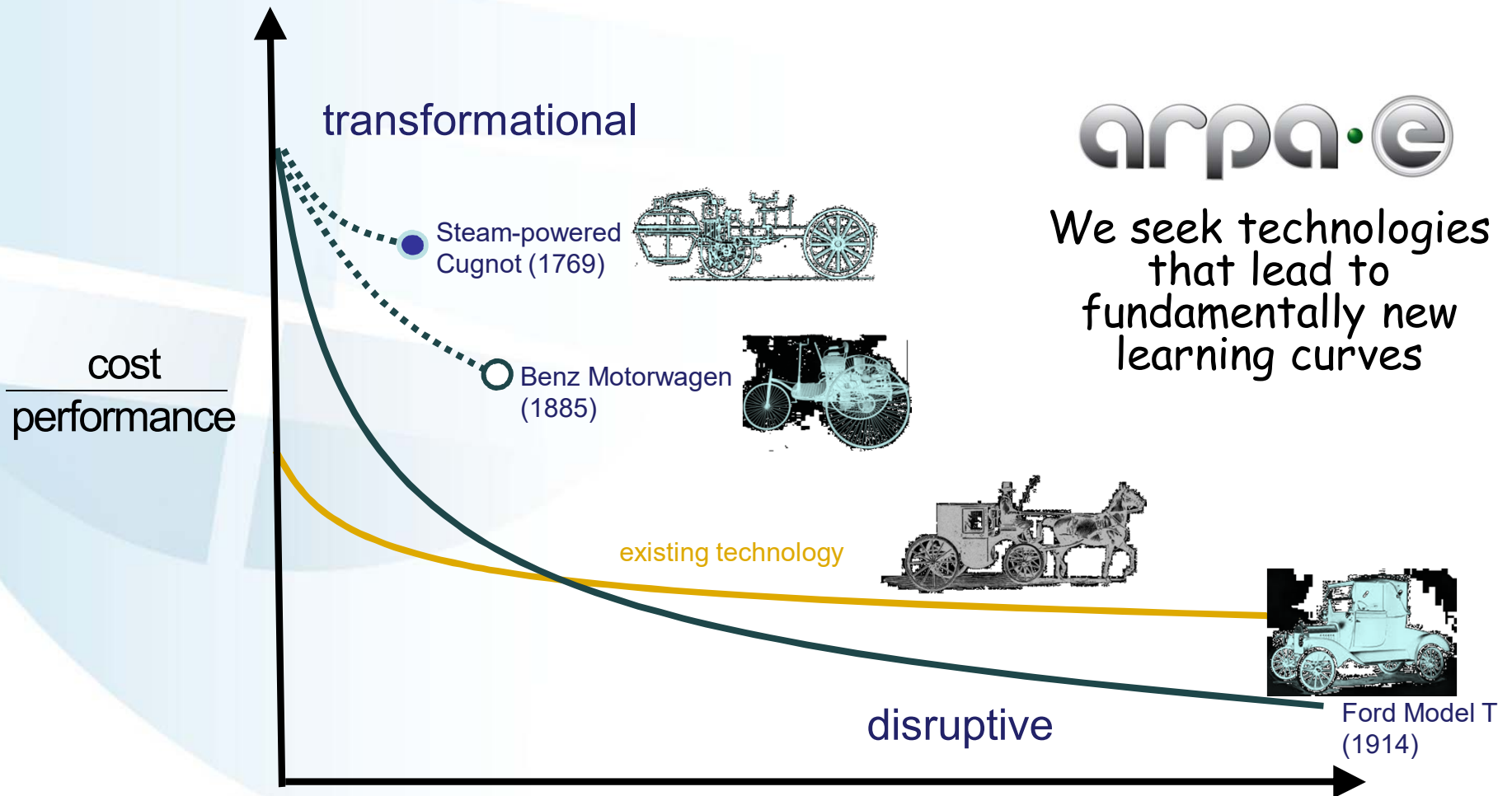


Images: L. National Archive, [www.archives.gov/research/american-cities/images/american-cities-101.jpg](http://www.archives.gov/research/american-cities/images/american-cities-101.jpg)  
R. [shorpy.com/node/204](http://shorpy.com/node/204)  
Inspiration: Tona Seba's keynote lecture at AltCar, Santa Monica CA, 28 Oct 2014,  
<http://tonaseba.com/keynote-at-altcar-expo-100-electric-transportation-100-solar-by-2030/>

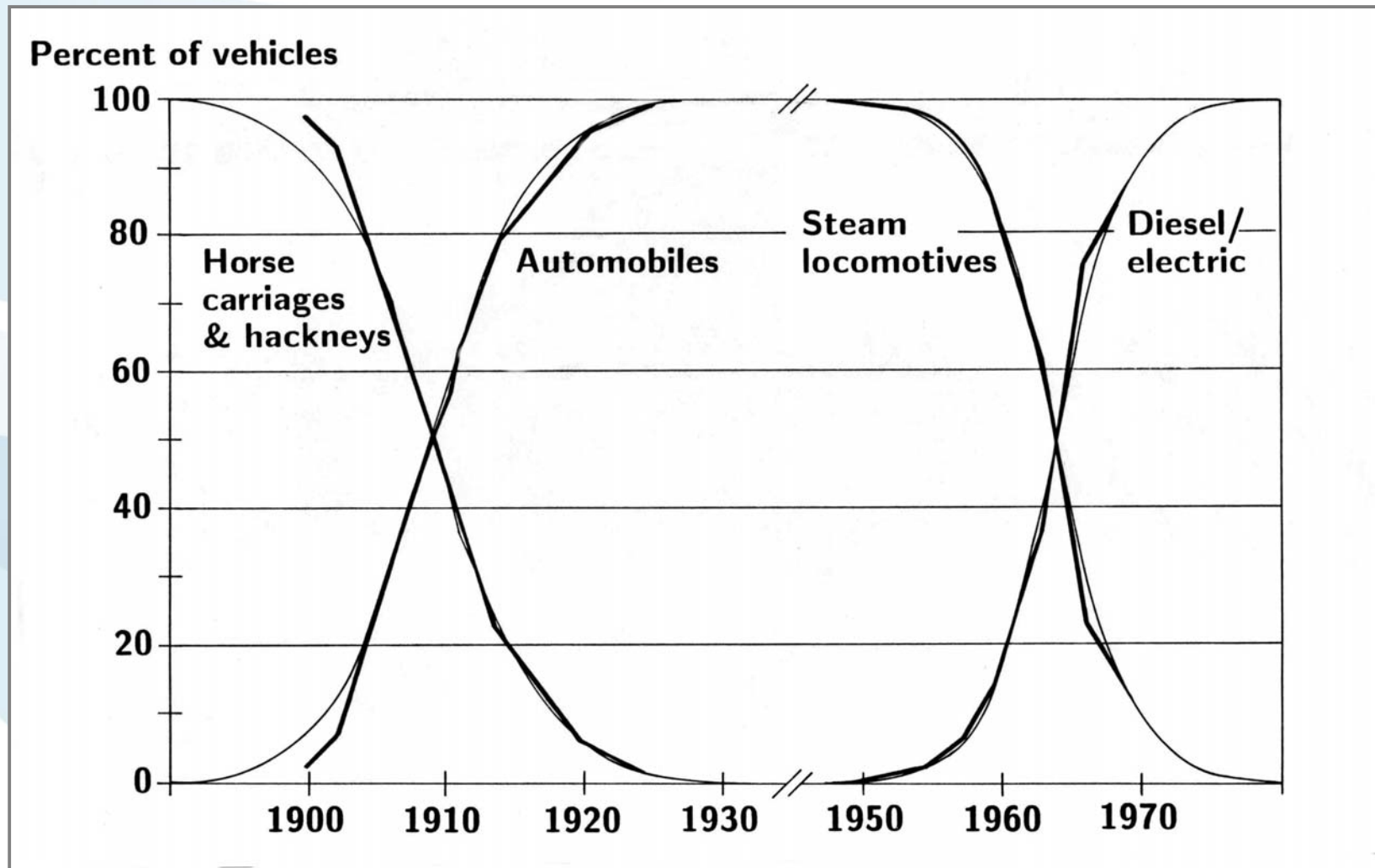
# Incremental & Disruptive Technologies



We seek technologies that lead to fundamentally new learning curves

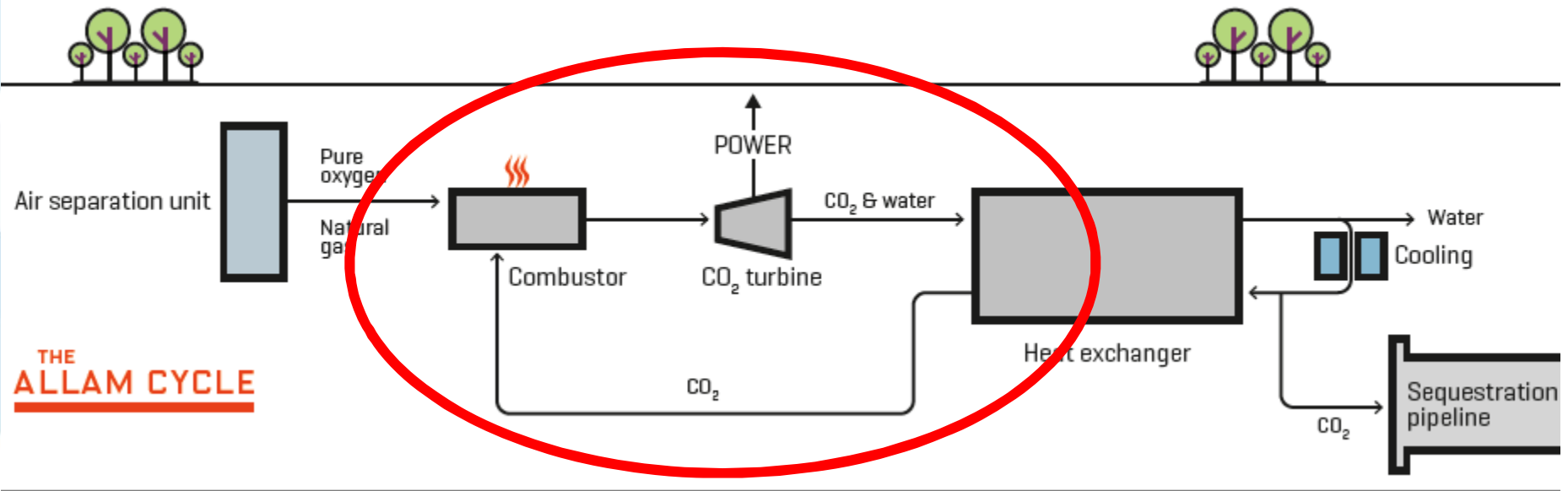


# UK – Replacement within Vehicle Fleets





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





# Possible transformational technologies



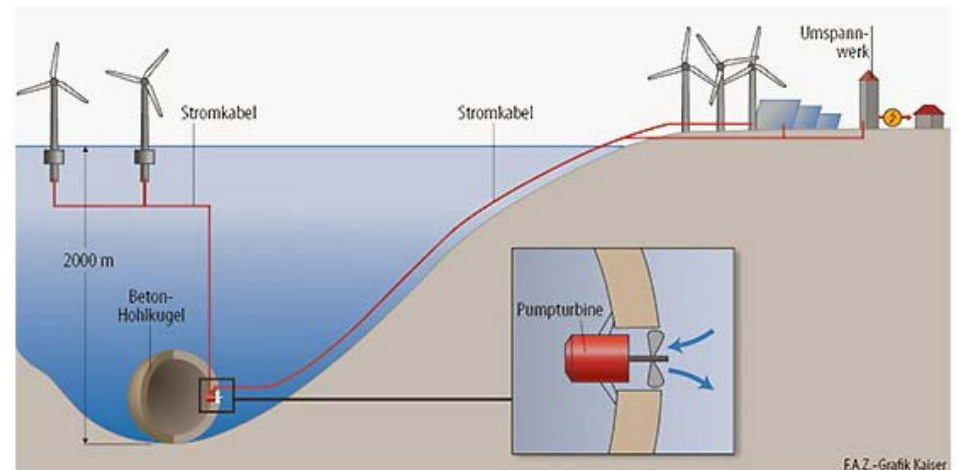
**Conventional Turbine Offshore Wind Farm;**

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

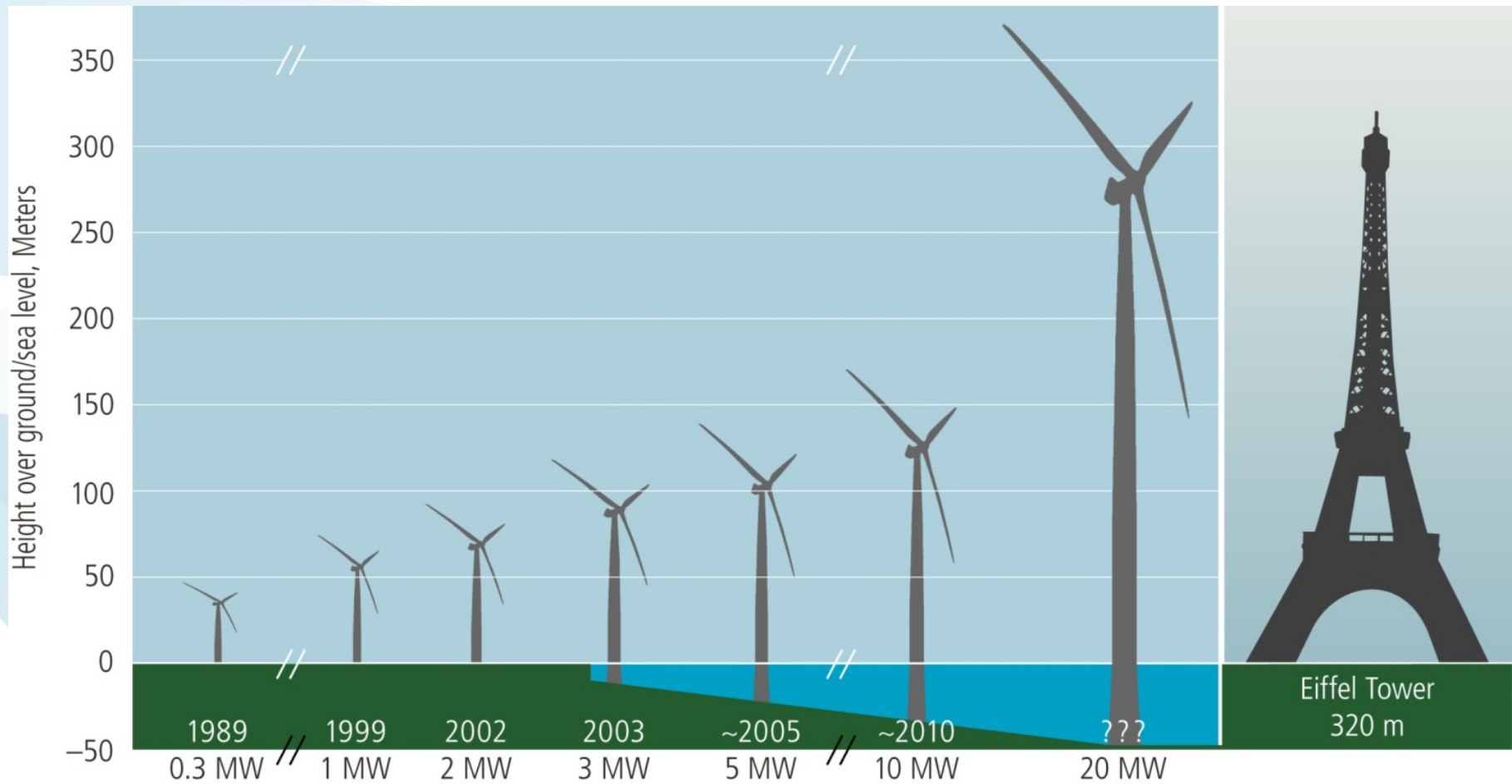
**Accelerator Turbine Offshore Wind Farm;**

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

STERLING



# “Learning” Through Scale



## Economies of scale, US wind turbines



**lumpy**  
large unit size  
high unit cost  
indivisible



**Granularity:  
Technology  
Unit  
Scales**



**granular**  
small unit size  
low unit cost  
modular





# Fast vs. Slow Transformations

**slow**

systemic

novel concepts,  
formative phases

lumpy technologies  
& infrastructures

early adopting markets

weak adopter benefits  
(mainly less externalities)

co-ordination problems,  
vested interests

**fast**

discrete technologies

market ready  
substitutes

granular technologies  
& social networks

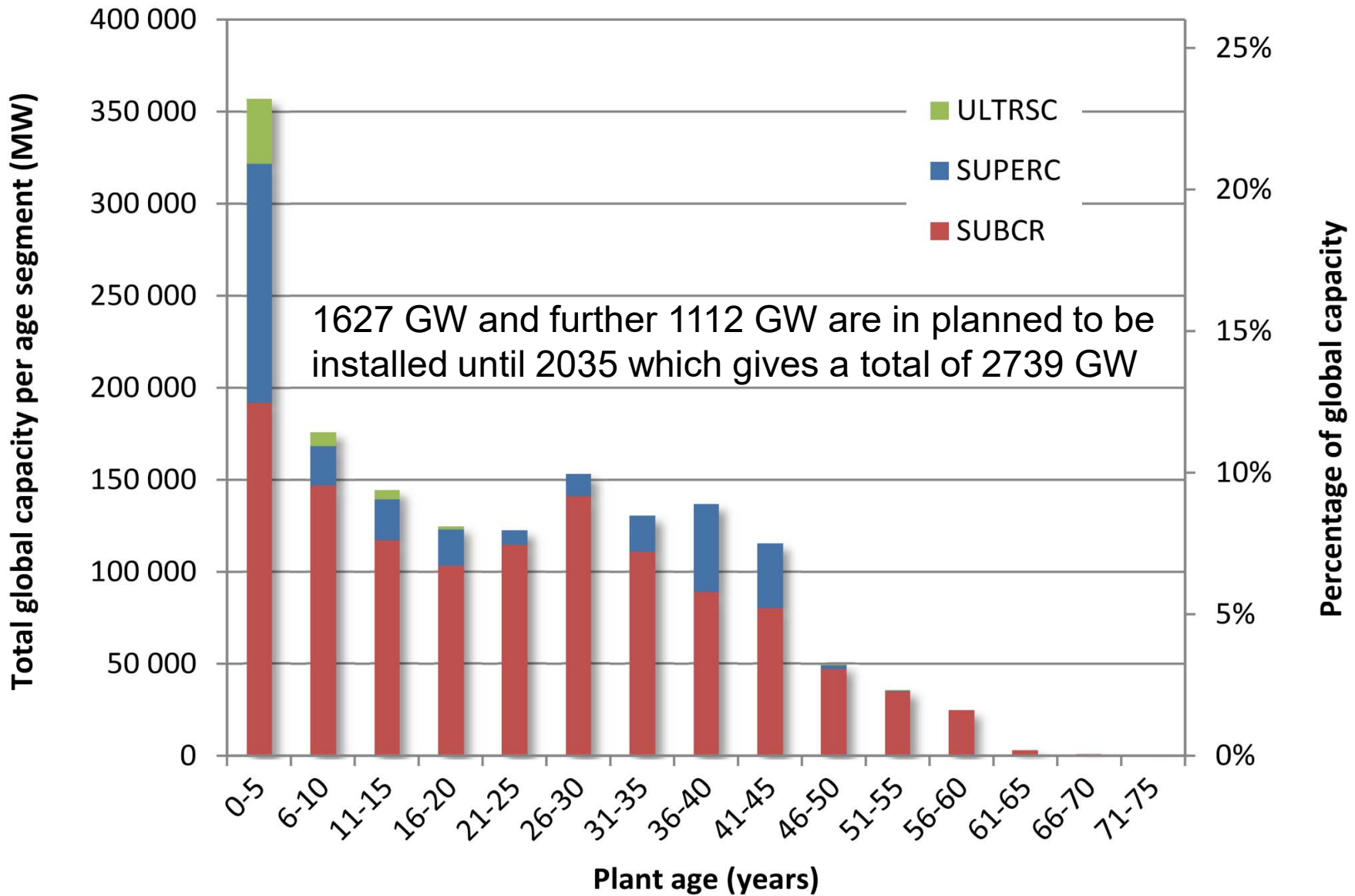
late adopting markets

strong adopter benefits,  
high relative advantage

strong co-ordination  
and policy direction

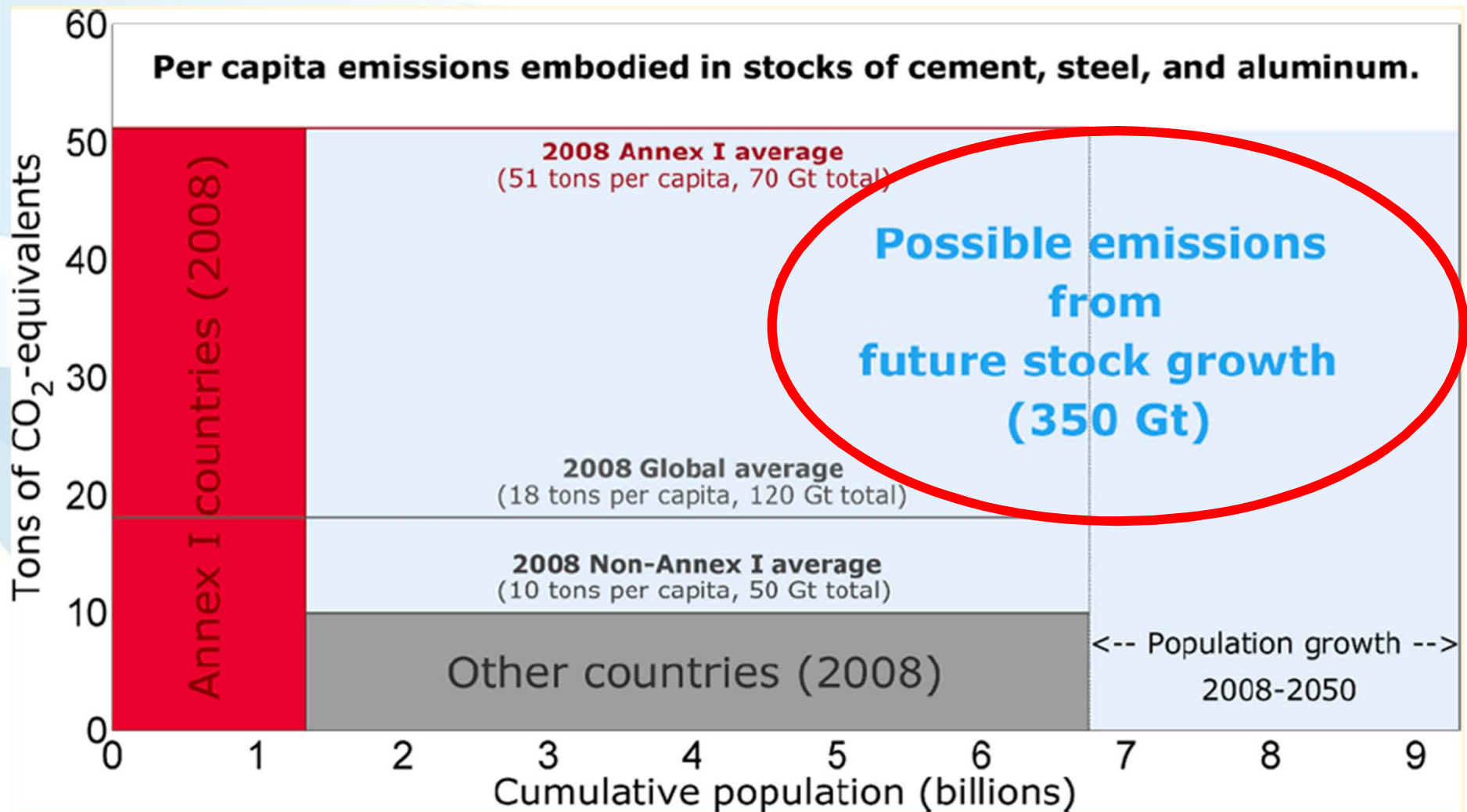


# Global Coal Power Plants



# Urban Embodied Emissions

Compared to Global Budget of 800 GtCO<sub>2</sub> for 2°C



# SuperGrid and MagLev Trains





# North-African Desertech



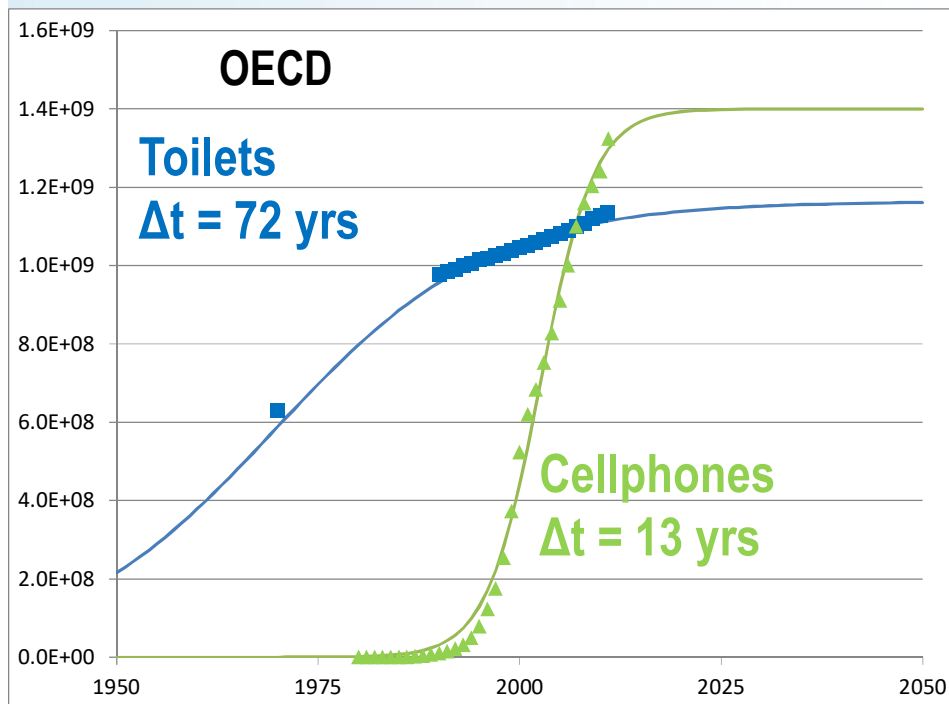




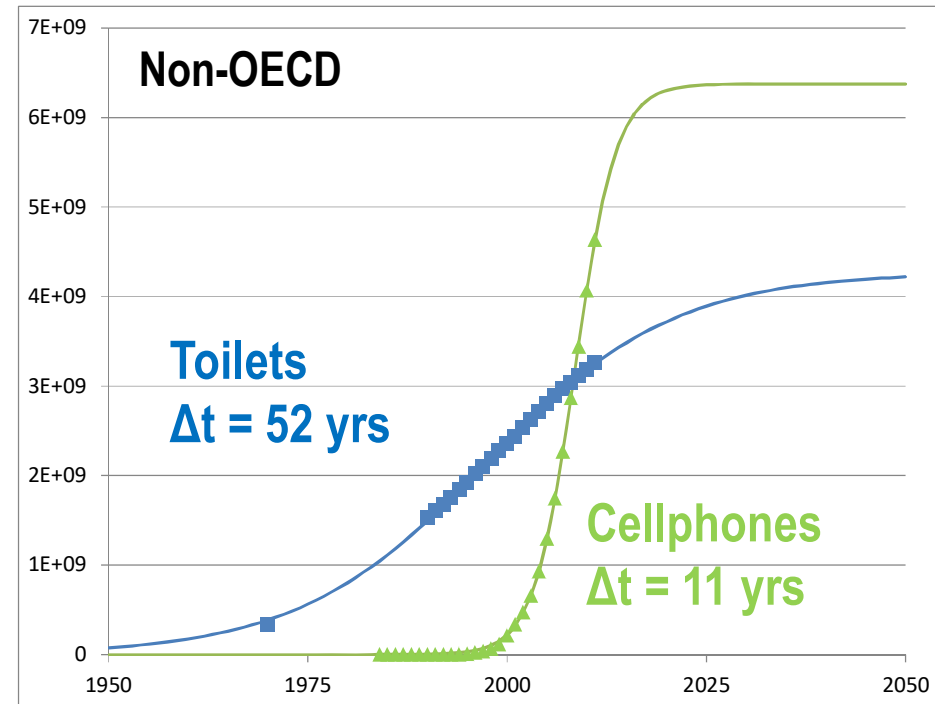
# Technology Diffusion Compared

(# of cellphones, people with access to safe sanitation)

K = 1.2-1.4 Billion



K = 4.3-6.4 Billion



**Why could cell phones reach 4 billion people within 10 years while 4 billion still lack access to safe sanitation after 100 years?**





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# THANK YOU

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