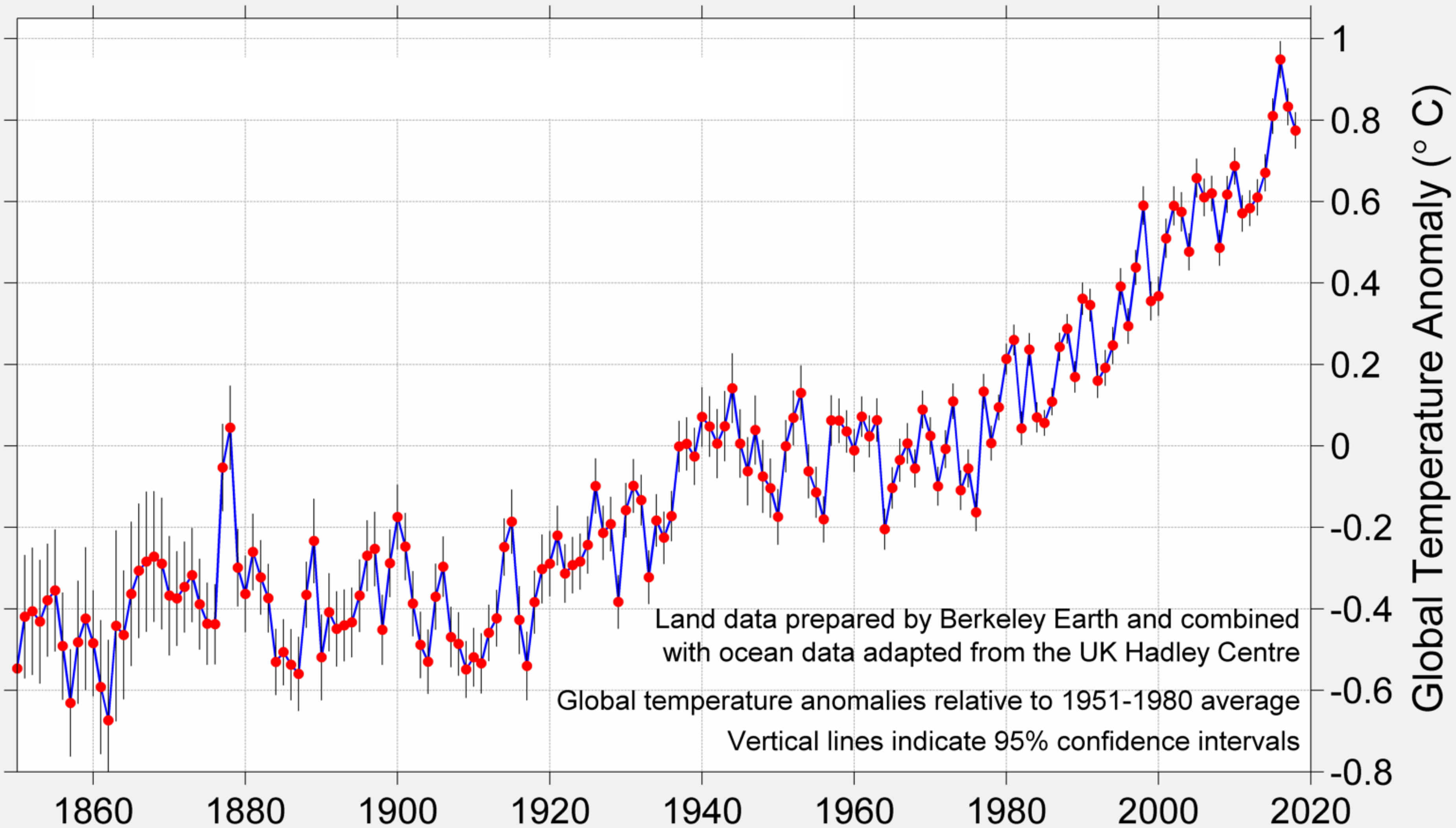
“New Energy for Czechia” Roundtable
Prague, 5 April 2019

The Climate Challenge and the Great Transformation

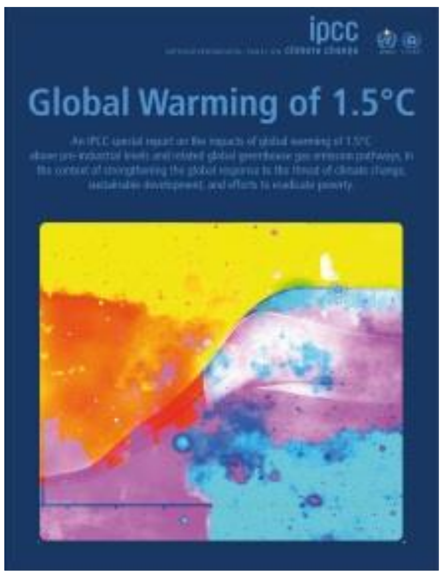
Professor H. J. Schellnhuber CBE
Director Emeritus, Potsdam Institute for Climate Impact Research

PIK

Global Mean Temperature 1850-2018



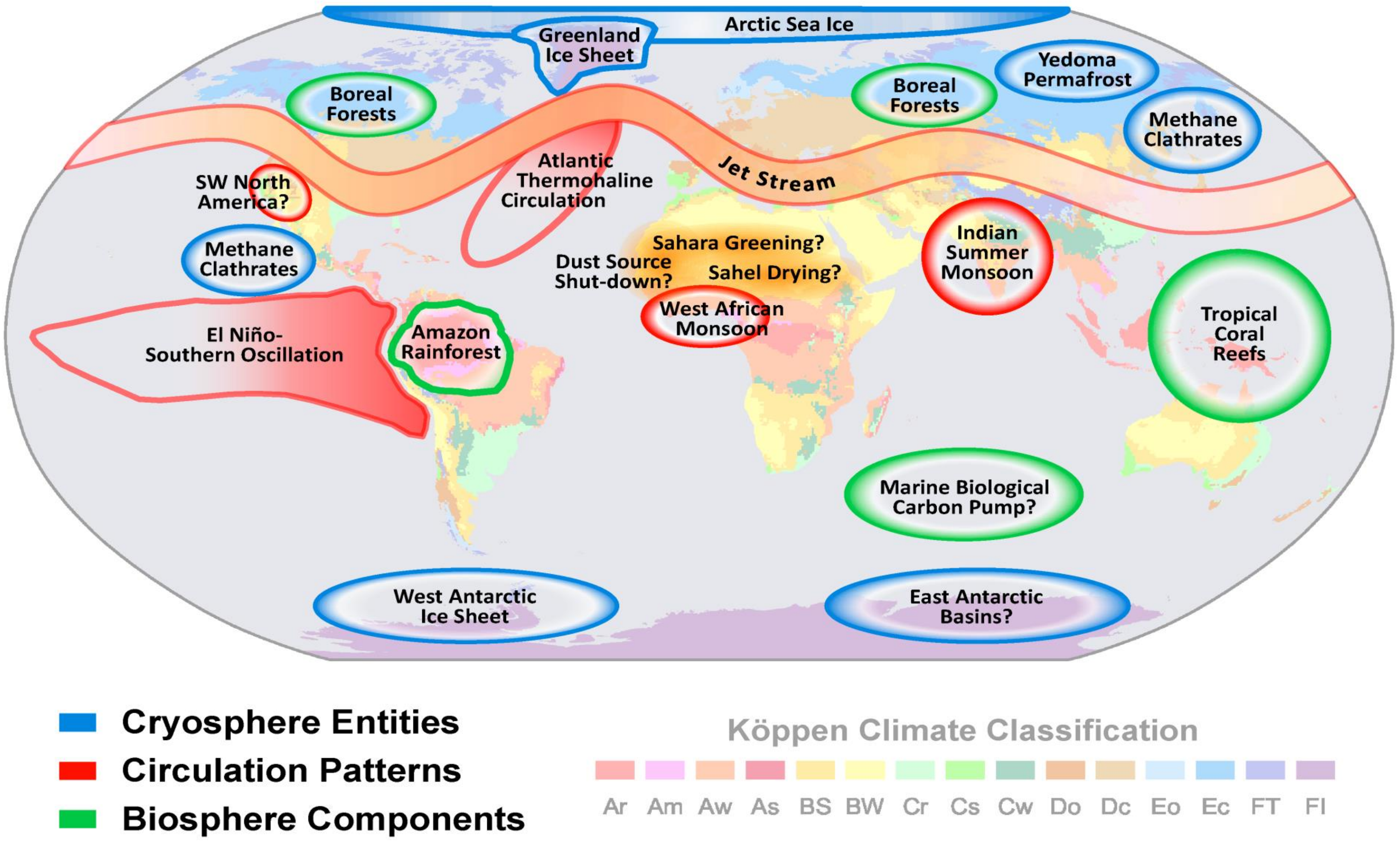

Global Warming of 1.5°C
#SR15
ipcc


ipcc
Global Warming of 1.5°C


IPCC
@IPCC_CH
Folgen
"Every half degree of warming matters" said IPCC Chair, Hoesung Lee on the Special Report on Global Warming of 1.5°C #SR15 #climatechange #ipcc #ParisAgreement
0:16 18,7 Tsd. Aufrufe
15:00 - 8. Okt. 2018
482 Retweets 585 „Gefällt mir"-Angaben

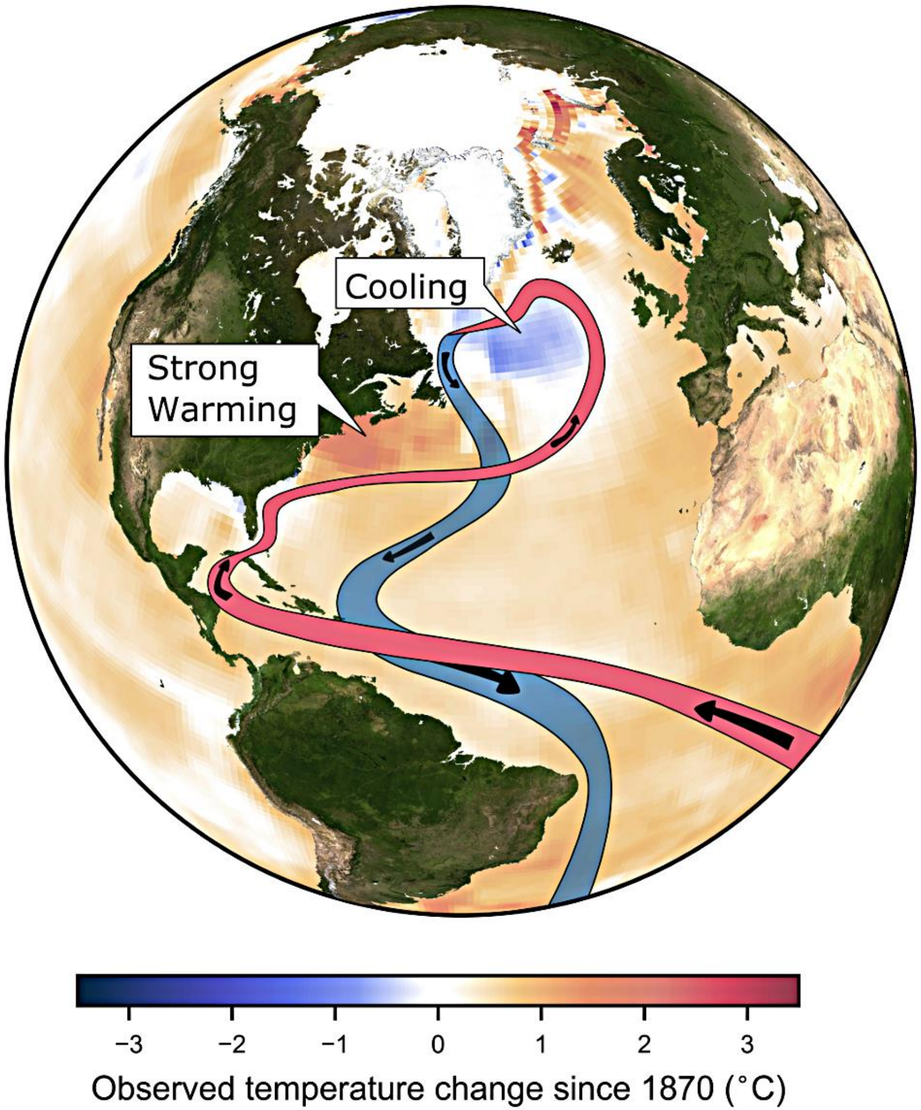

ipcc
climate change
Forty-Eighth Session of the IPCC and
First Joint Session of Working Groups I, II and III
1-5 October 2018 Incheon, Republic of Korea

Looming Risks: Tipping Elements in the Earth System



PIK 2017

Stronger Evidence for a Weaker Atlantic Overturning

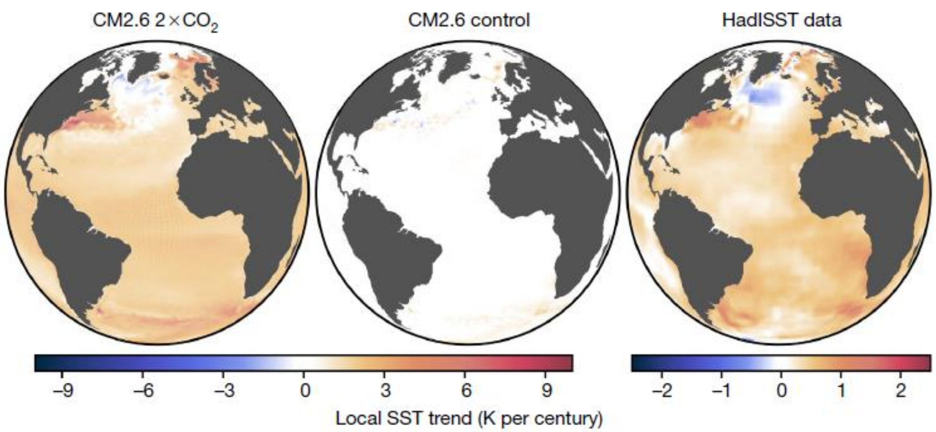


https://doi.org/10.1038/s41586-018-0006-5

Observed fingerprint of a weakening Atlantic Ocean overturning circulation

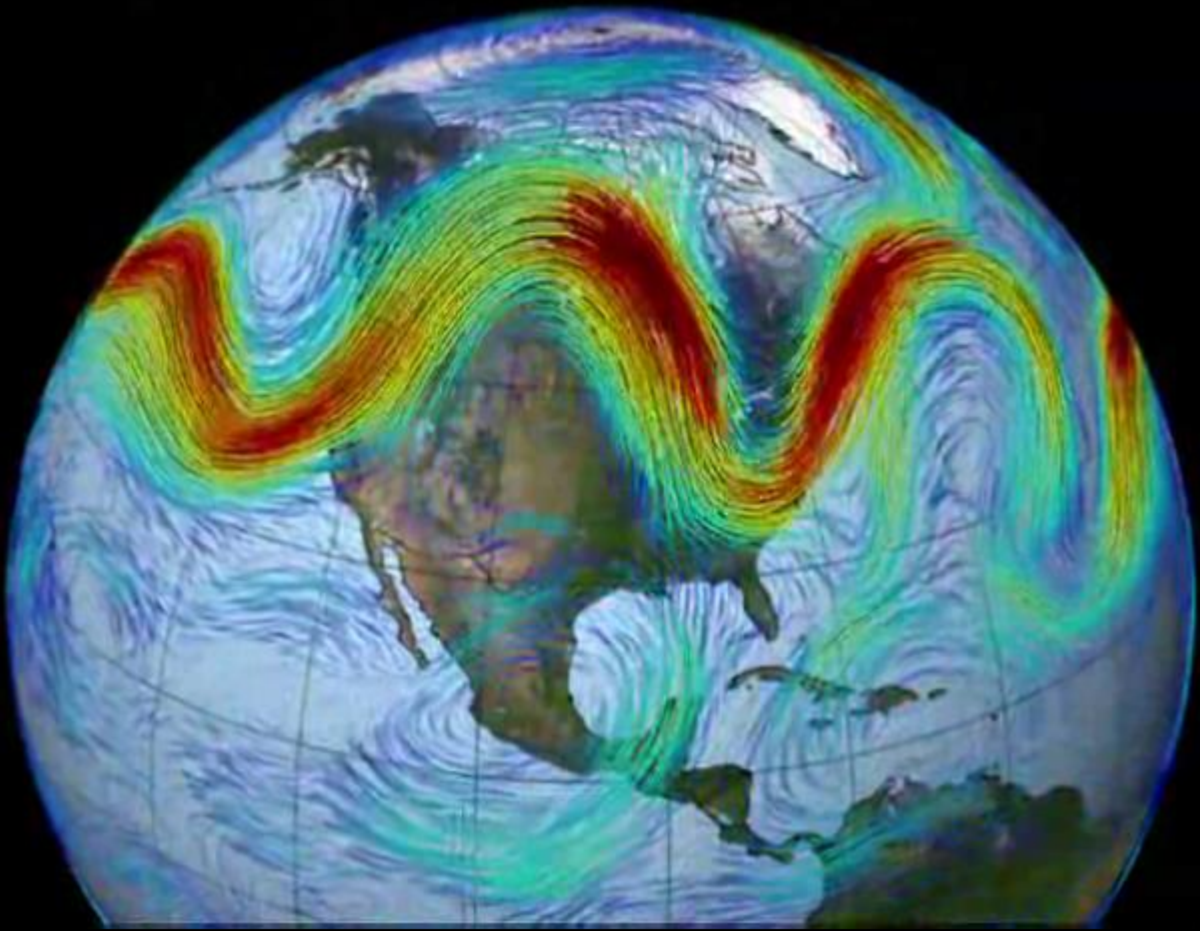
L. Caesar[1,2]*, S. Rahmstorf[1,2]*, A. Robinson[1,3,4,5], G. Feulner[1] & V. Saba[6]

The Atlantic meridional overturning circulation (AMOC)—a system of ocean currents in the North Atlantic—has a major impact on climate, yet its evolution during the industrial era is poorly known owing to a lack of direct current measurements. Here we provide evidence for a weakening of the AMOC by about 3 ± 1 sverdrups (around 15 per cent) since the mid-twentieth century. This weakening is revealed by a characteristic spatial and seasonal sea-surface temperature 'fingerprint'—consisting of a pattern of cooling in the subpolar Atlantic Ocean and warming in the Gulf Stream region—and is calibrated through an ensemble of model simulations from the CMIP5 project. We find this fingerprint both in a high-resolution climate model in response to increasing atmospheric carbon dioxide concentrations, and in the temperature trends observed since the late nineteenth century. The pattern can be explained by a slowdown in the AMOC and reduced northward heat transport, as well as an associated northward shift of the Gulf Stream. Comparisons with recent direct measurements from the RAPID project and several other studies provide a consistent depiction of record-low AMOC values in recent years.



Caesar et al. 2018, Nature

Meandering of the Jet Stream



Animation

NASA Goddard Space Flight Center

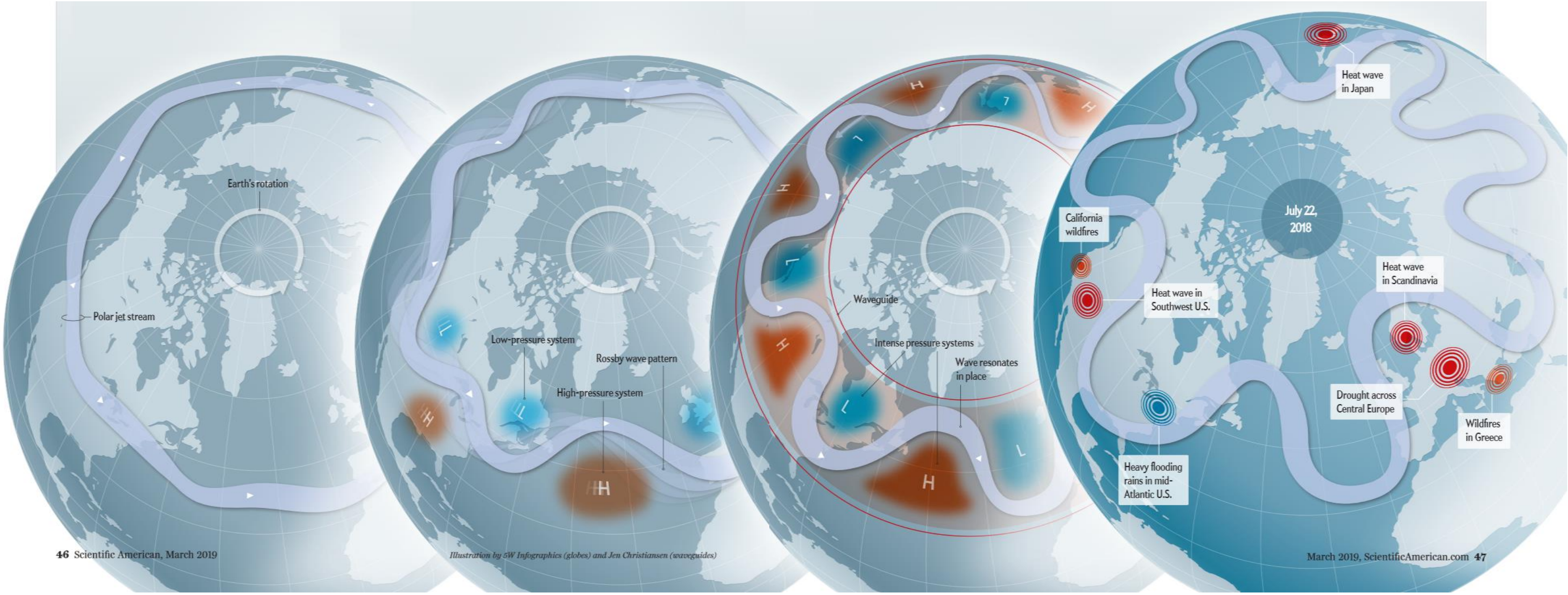
Pethoukov-Effect:
Rossby waves related to extreme weather events

Polar jet stream

Bends create low-pressure and high-pressure systems

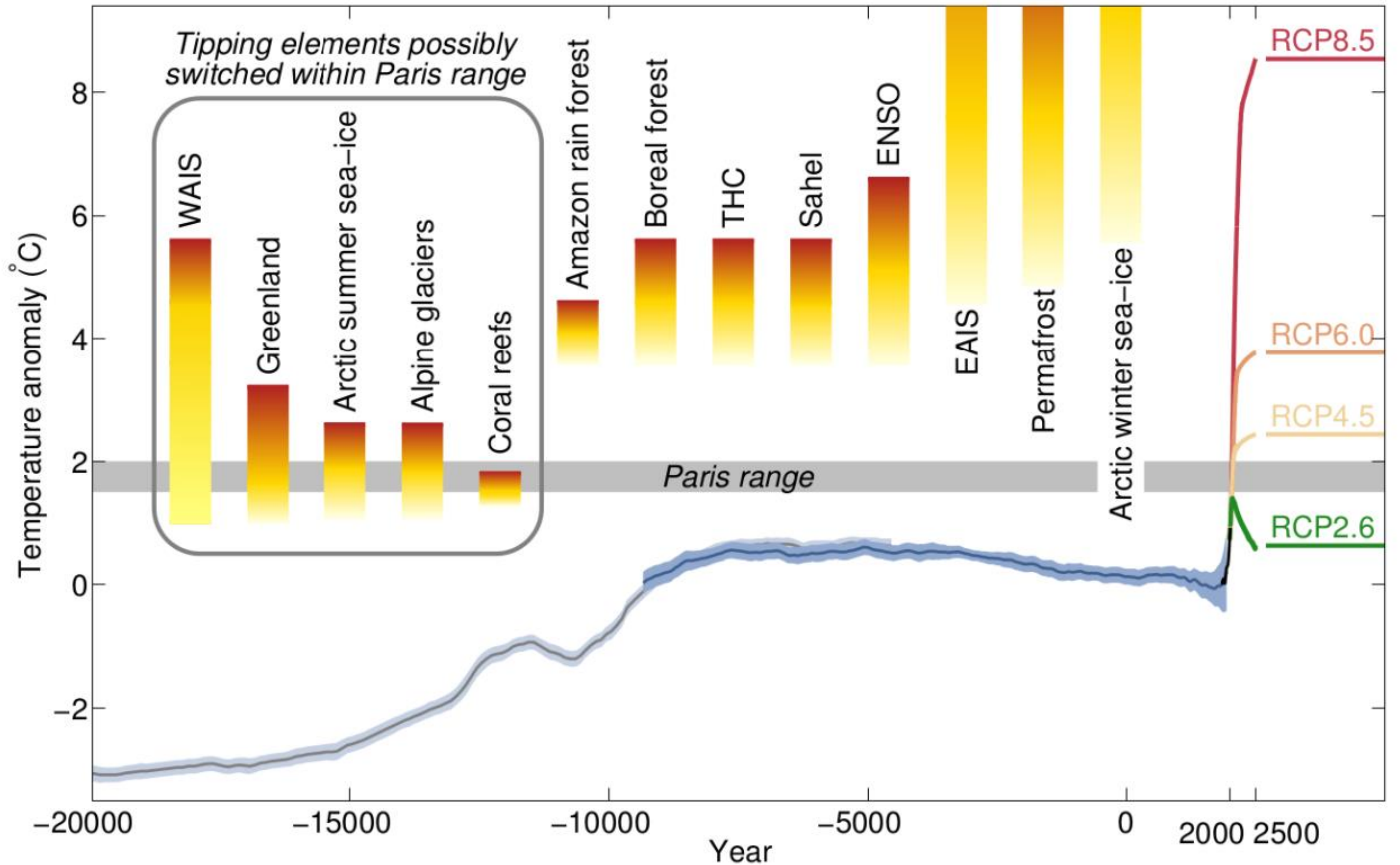
Formation of Rossby waves

Extreme weather events (e.g. 2018)



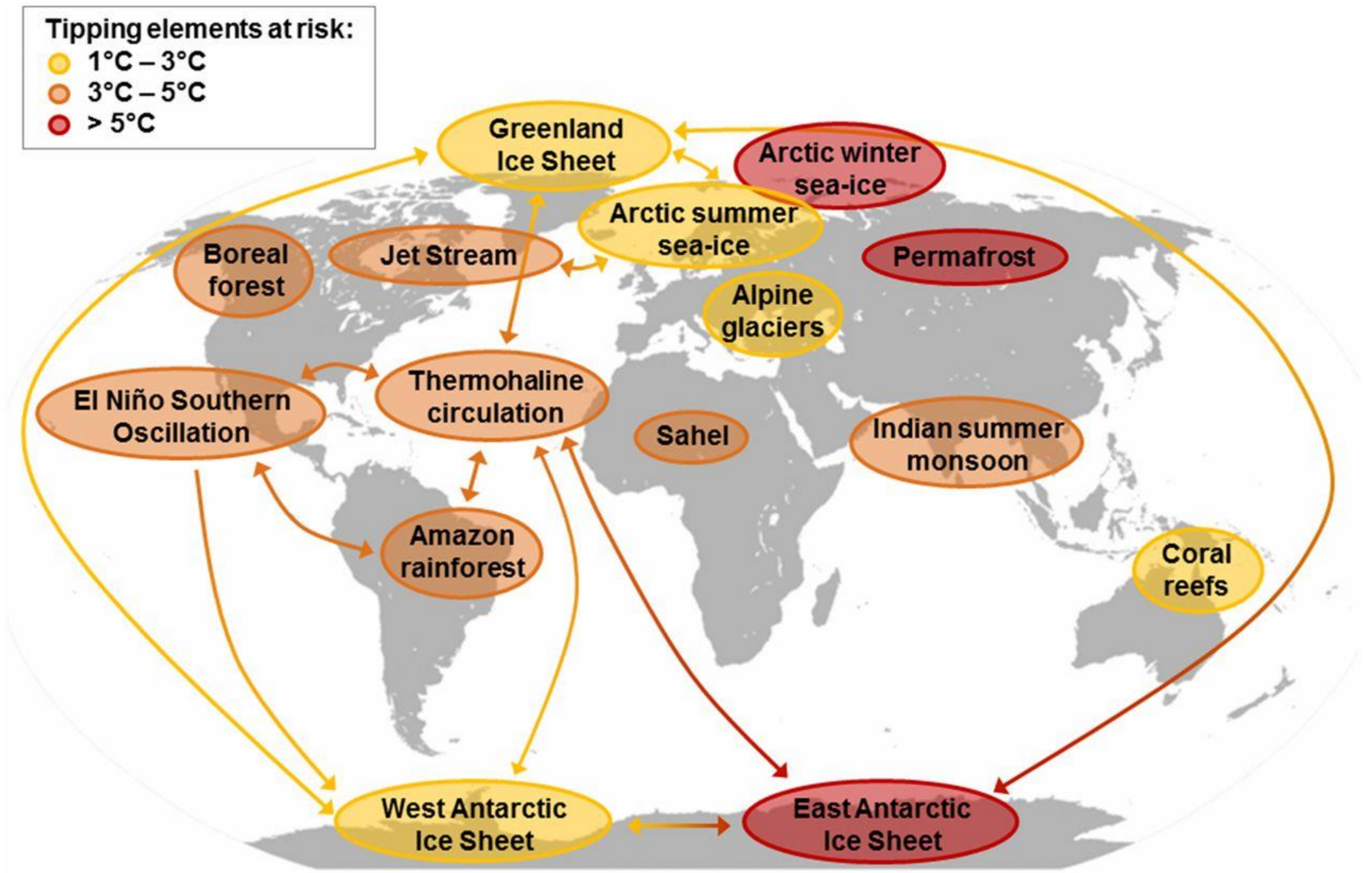
Pethoukov et al., PNAS, 2013
Graphic: Mann, M., Scientific American, 2019

Tipping Points Related to 2°C-Guardrail



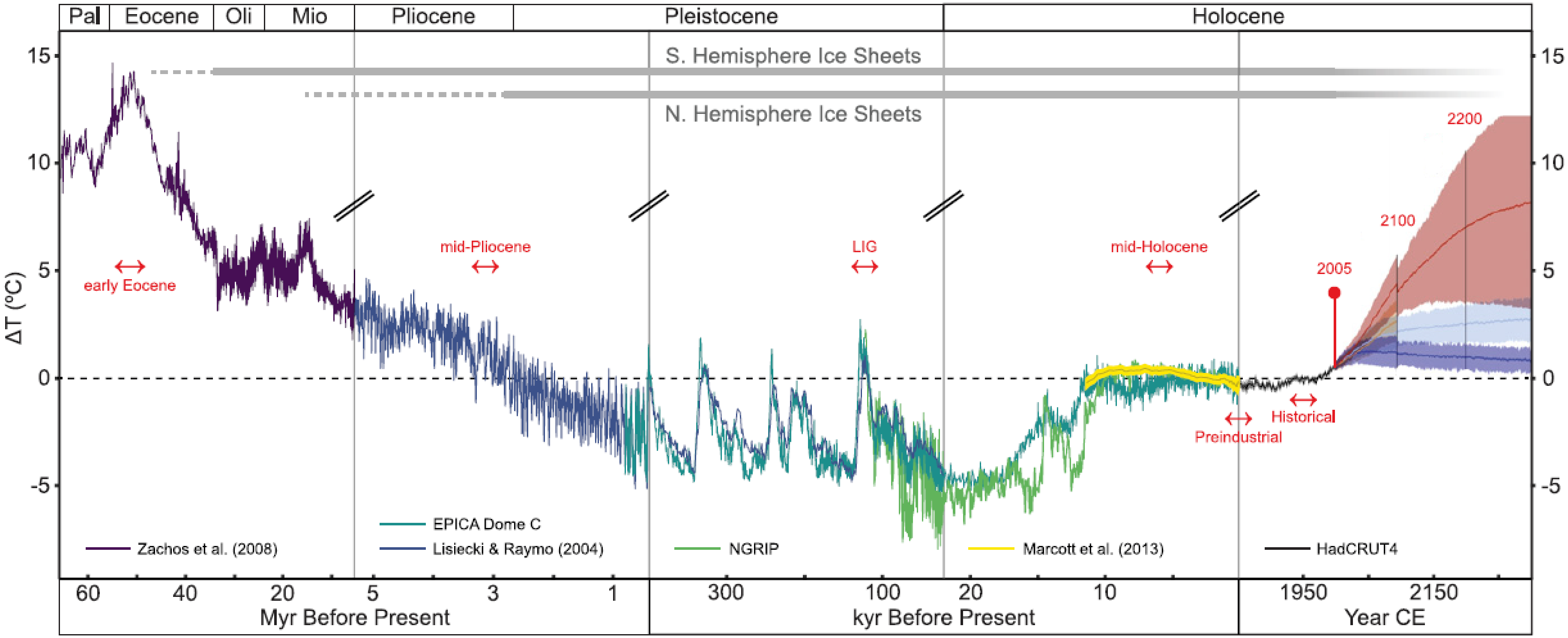
Schellnhuber et al. , Nature Climate Change, 2016

Global Map of Potential Tipping Cascades



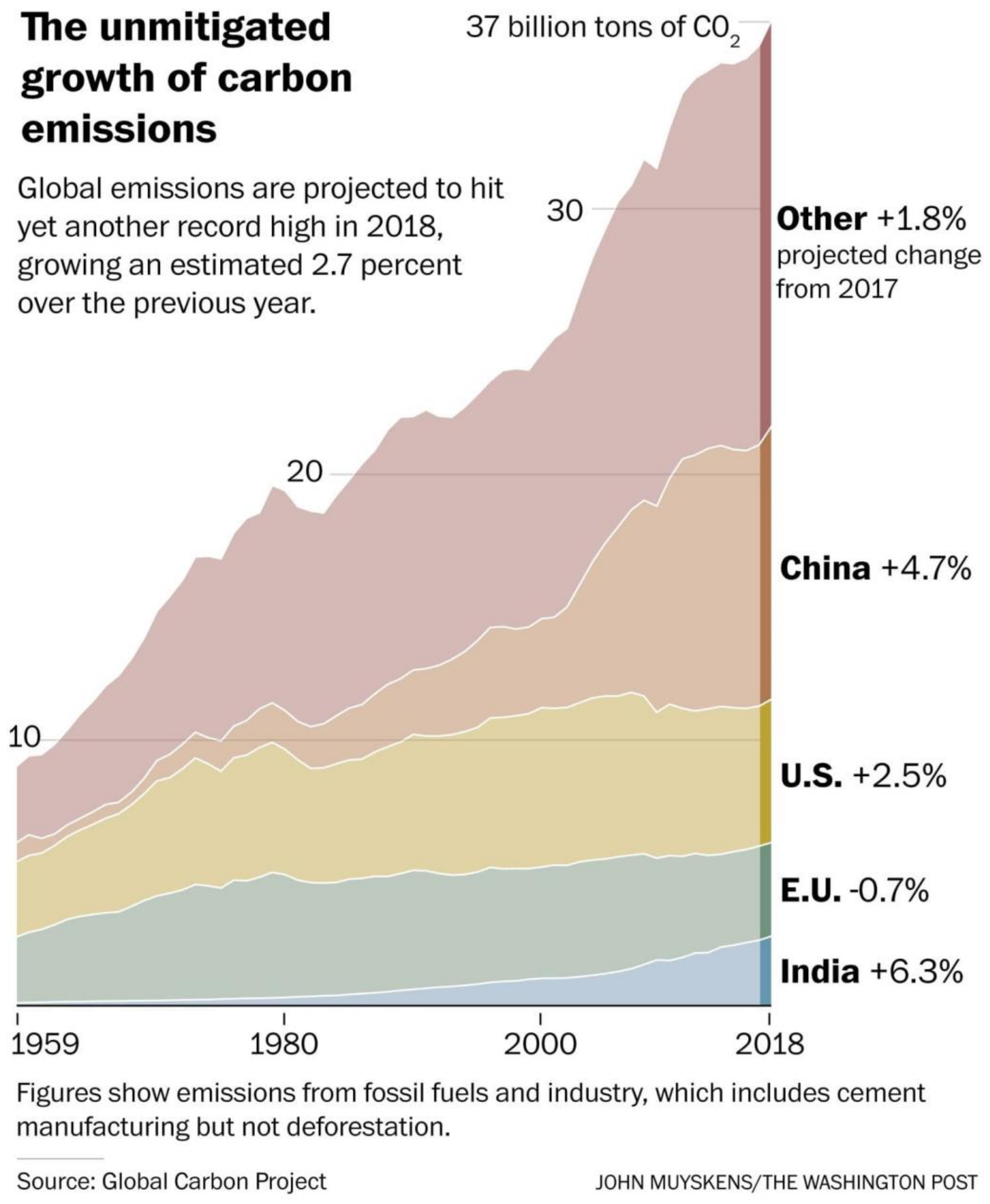
Steffen et al, 2018, PNAS

Temperature Trends for the Past 65 Ma and Potential Geohistorical Analogs for Future Climates



Burke et al. 2018, PNAS

‘We are in trouble’. Global carbon emissions reached a record high in 2018



nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-018-07223-9

OPEN

Warming assessment of ... Paris Agreement emissi...

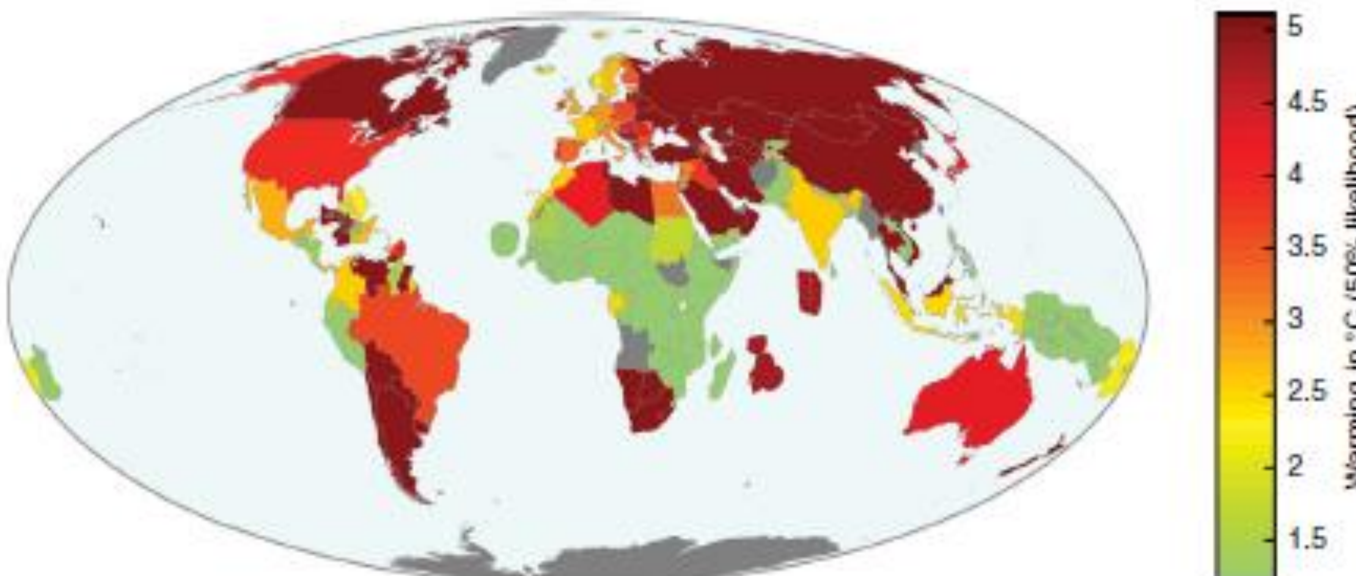
Yann Robiou du Pont [1] & Malte Meinshausen [1]

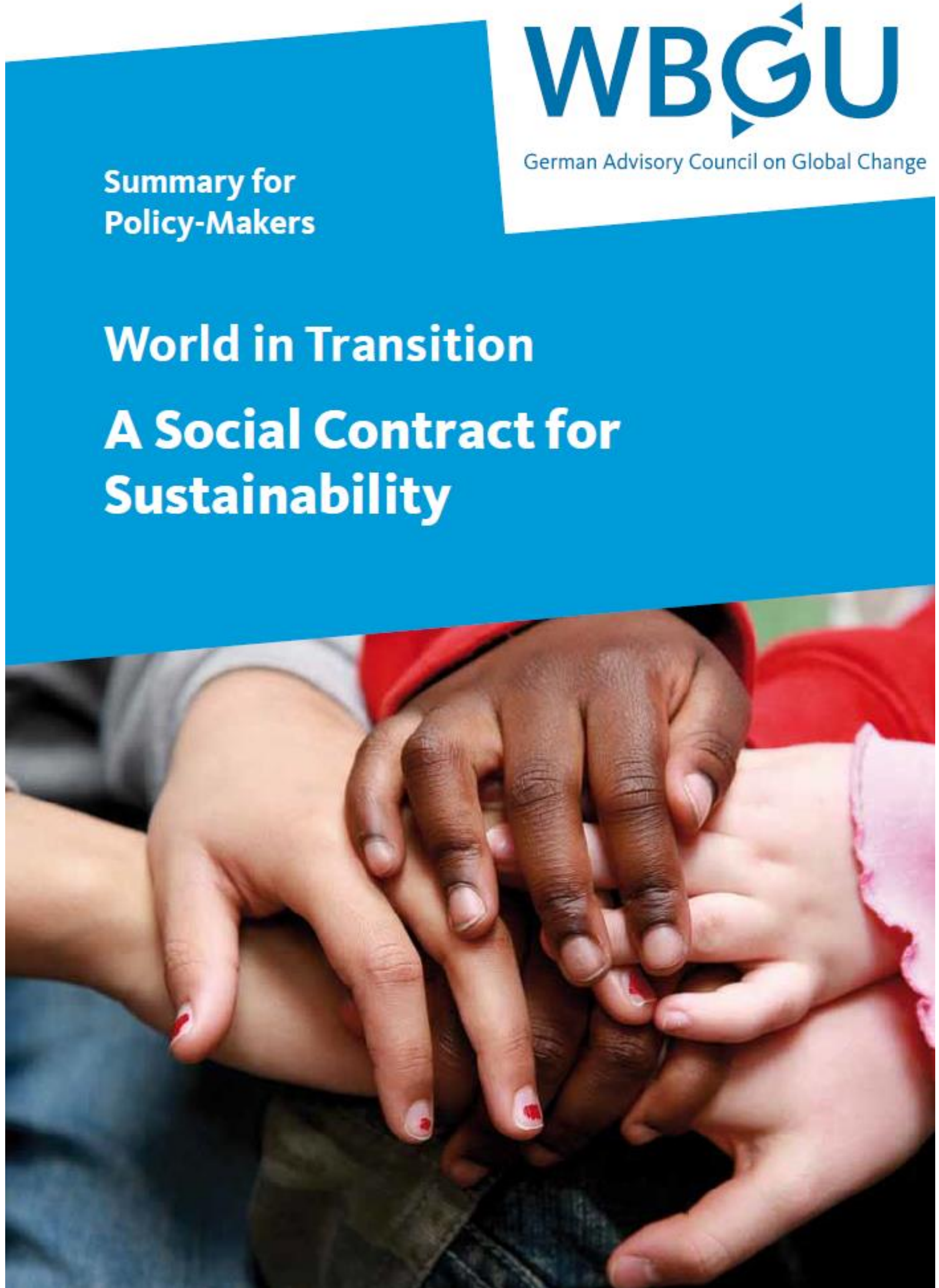
Under the bottom-up architecture of the Paris Agr... Determined Con... (NDCs). Current NDCs inc... concepts of equ... inconsistent w... the global 203... stringent of f... a self-intere... 2.3 °C. Tigh... levels of 1... tively. Th... with its... When... lead...

Policies of China, Russia and Canada threaten 5C climate change, study finds

Ranking of countries' goals shows even EU on course for more than double safe level of warming

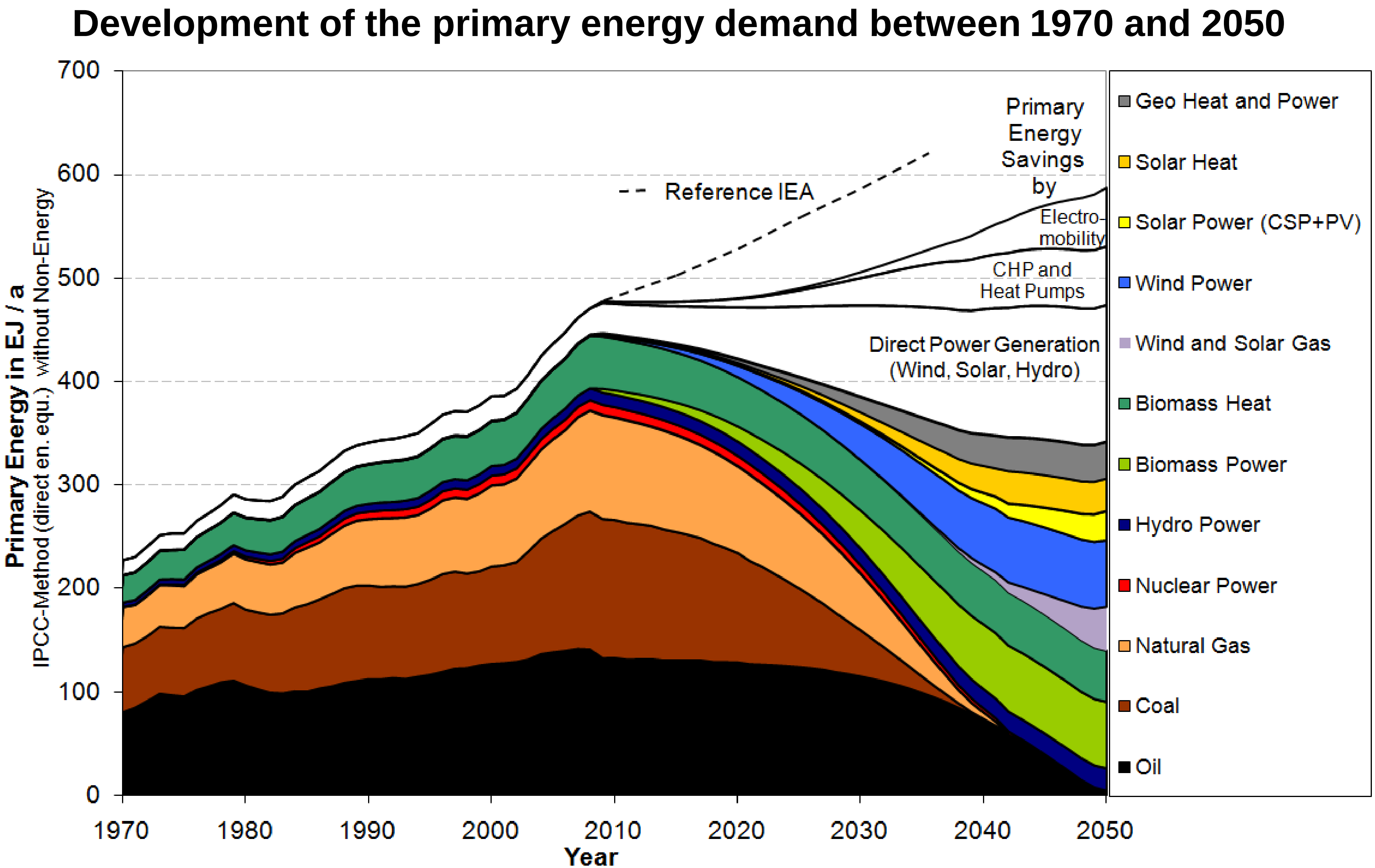
The Guardian 16 November 2018




WBGU
German Advisory Council on Global Change
Summary for Policy-Makers
World in Transition
A Social Contract for Sustainability

WGBU 2011

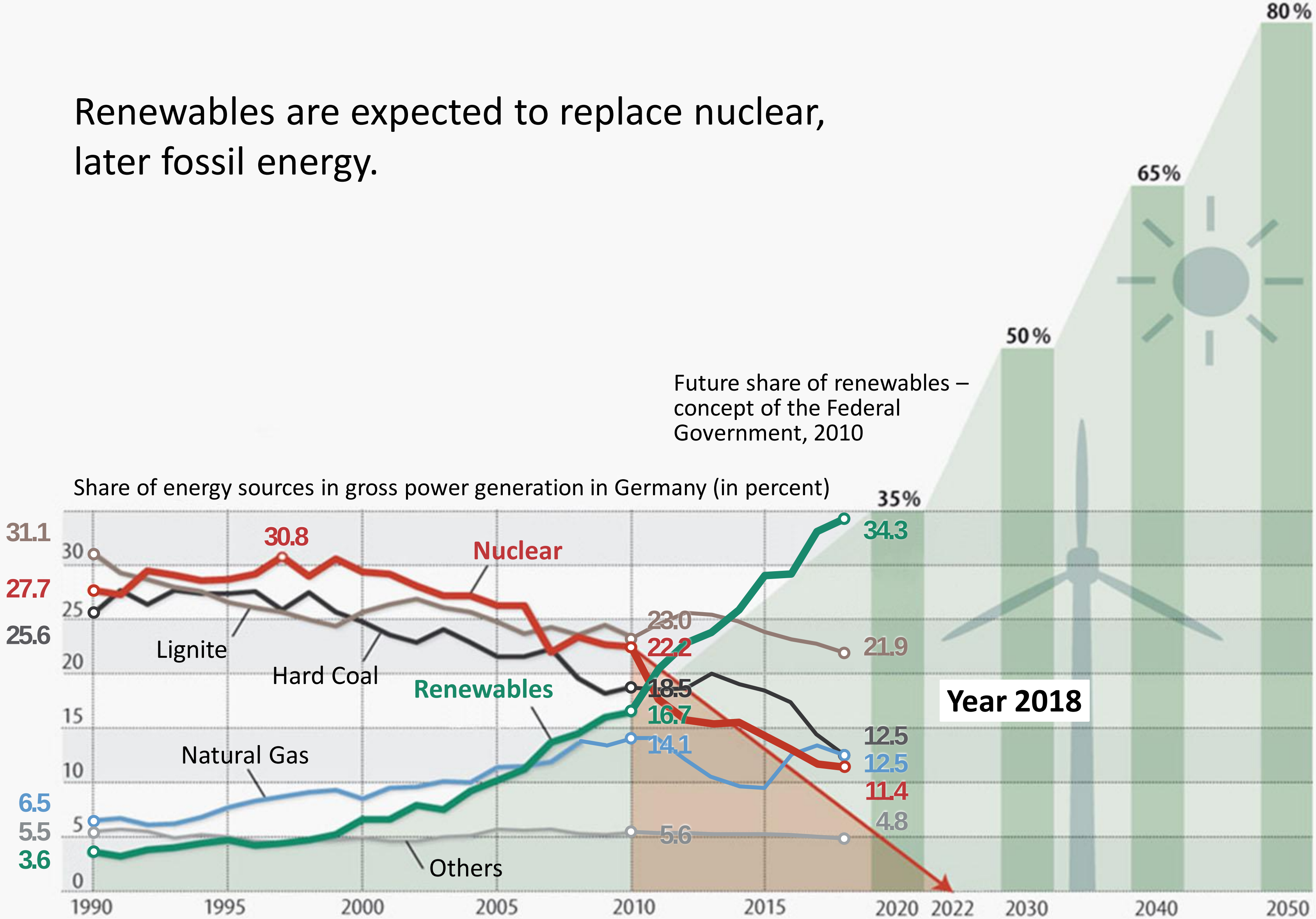
WBGU Vision of Global Energy Revolution



Source: WBGU 2011

"Energiewende" in Germany

Renewables are expected to replace nuclear, later fossil energy.



Quellen: Bundesregierung; Bundesumweltministerium; Umweltbundesamt; Statistisches Bundesamt; Statistische Landesämter; Bundesanstalt für Geowissenschaften und Rohstoffe; Deutsche Energie-Agentur (dena); eigene Berechnungen
Aktualisierung bis 2019 durch PIK nach BMWi: Zahlen und Fakten – Energiedaten (2019).

FAZ, June 2011; updated 2019

German Commission Designing Coal Phase-out

German Commission
Designing Coal Phase-out

The Commission’s pensum:

- 16 full-time meetings over half a year
- Hearings of more than 60 experts
- Three journeys to the districts
- 21 hours of final negotiations

The Commission’s results:

- Exit of coal-fired power stations until 2038, optionally 2035
- Agreement on phase-out pathway:
  - 2022: 15 GW lignite + 15 GW hard coal (minus 12,7 GW compared to 2017)
  - 2030: 9 GW lignite + 8 GW hard coal (aiming for a continuous reduction pathway starting 2022)
- Extensive support of affected states: €40 billion over 20 years
- Extensive measures for employees and, as far as possible, conjoint solutions with power station operators
- Considerable electricity price compensation

The road to global decarbonization must involve renewable energy, as from these wind turbines in Germany, and improved transportation technologies.

CLIMATE POLICY

A roadmap for rapid decarbonization

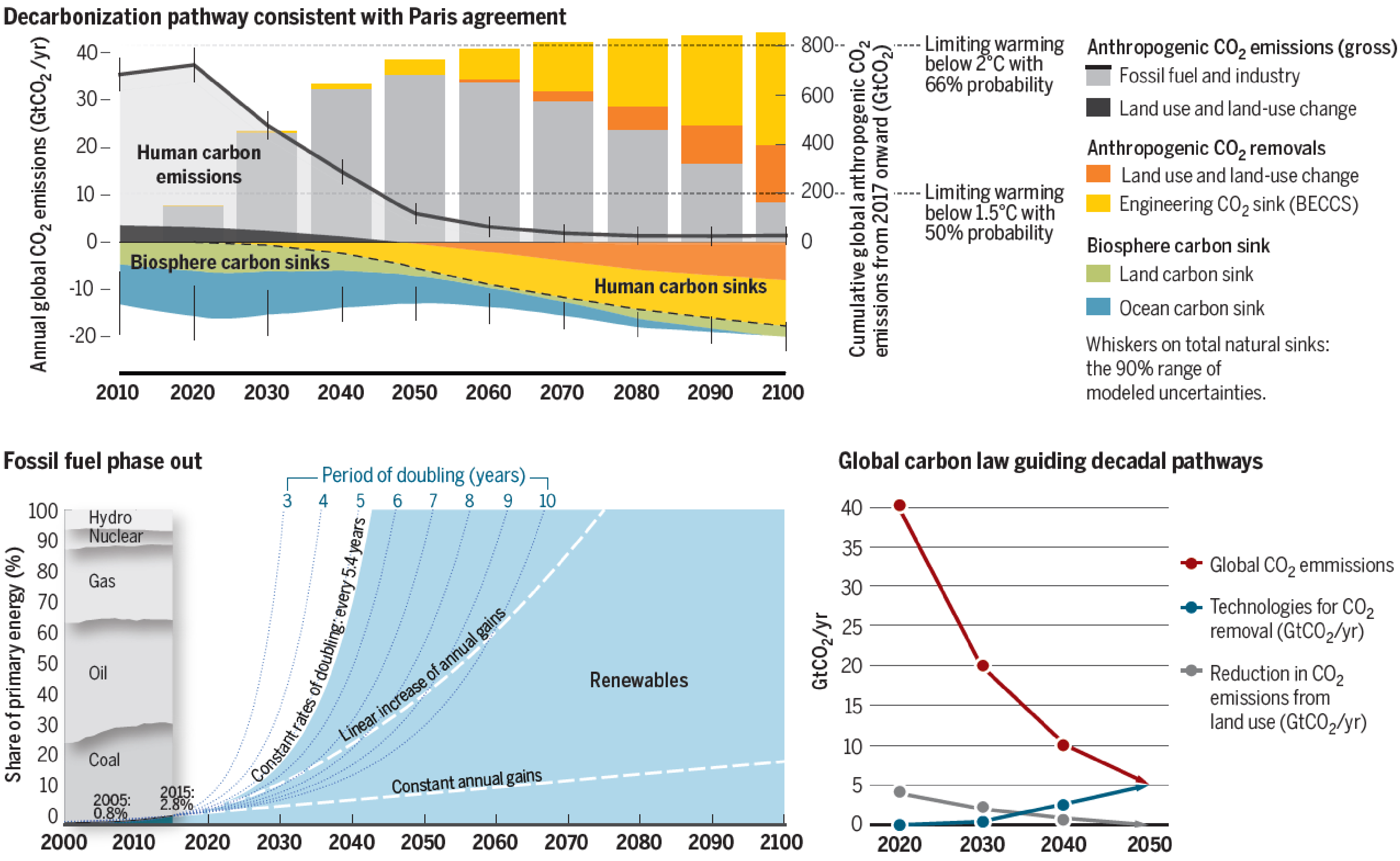
Emissions inevitably approach zero with a "carbon law"

By **Johan Rockström,[1] Owen Gaffney,[1,2] Joeri Rogelj,[3,4] Malte Meinshausen,[5,6] Nebojsa Nakicenovic,[4] Hans Joachim Schellnhuber[1,5]**

pose framing the decarbonization challenge in terms of a global decadal roadmap based on a simple heuristic—a "carbon law"—of halving gross anthropogenic carbon-dioxide (CO_2) emissions every decade. Complesistent with the trajectory of the past decade (see the figure, bottom left). All sectors (e.g., agriculture, construction, finance, manufacturing, transport) need comparable transformation pathways. In addition, in the absence of viable alternatives, the world must aim at rapidly scaling up CO_2 removal by technical means from zero to at least 0.5 $GtCO_2$/year by 2030, 2.5 by 2040, and 5 by 2050. CO_2 emissions from land-use must decrease along a nonlinear trajectory from 4 $GtCO_2$/year in 2010, to 2 by 2030, 1 by 2040, and 0 by 2050 (see the figure, bottom right). The endgame is for cumulative CO_2 emissions since 2017 to be brought back from around 700 $GtCO_2$ to below 200 $GtCO_2$ by the end of the century (see the figure, top) and atmospheric CO_2 concentrations to return to 380 ppm by 2100 (currently at 400 ppm).

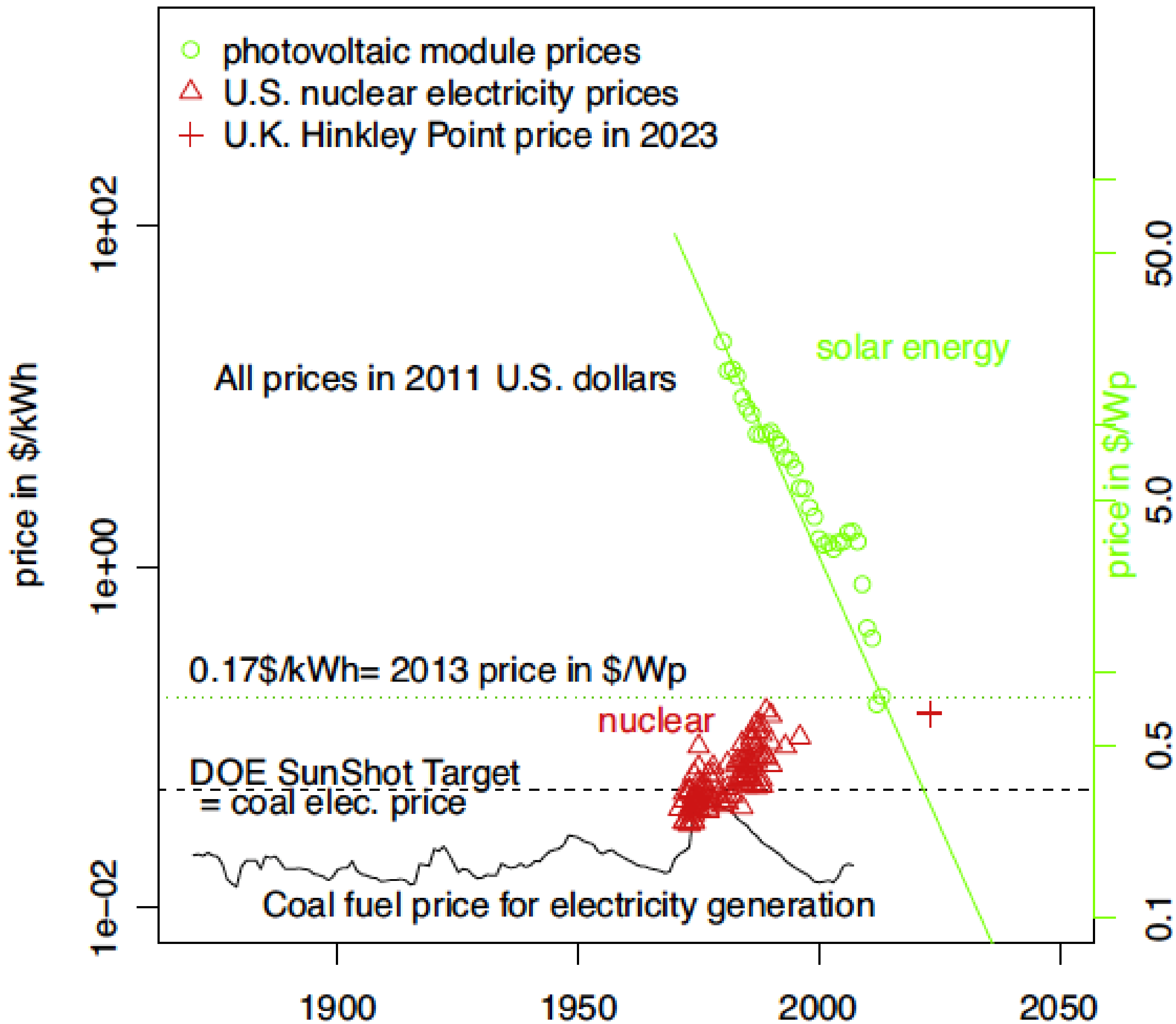
Roadmaps are planning instruments, linking shorter-term targets to longer-term goals. They help align actors and organizations to instigate technological and institutional breakthroughs to meet a collective challenge. An explicit carbon roadmap for halving anthropogenic emissions every decade, codesigned by and for all industry sectors, could help promote disruptive, nonlinear technological advances toward a zero-emissions world. The

The Transformation Roadmap



Rockström et al., Science 2017

Technologies Beat Commodities – Renewables Will Win (But Not Fast Enough)



Source: Farmer and Lafond (2016)

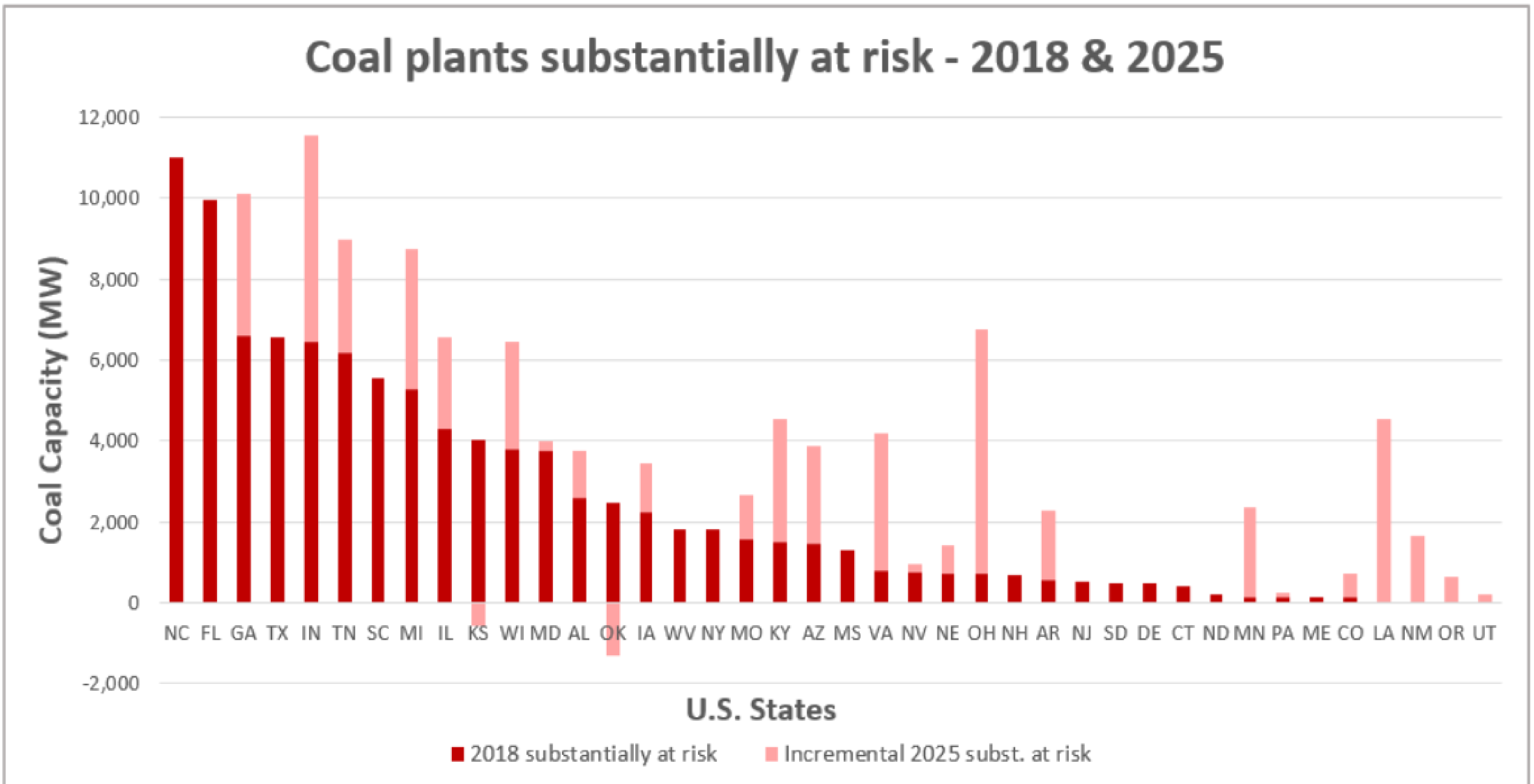
The Guardian

'Coal is on the way out': study finds fossil fuel now pricier than solar or wind

Oliver Milman *in New York*

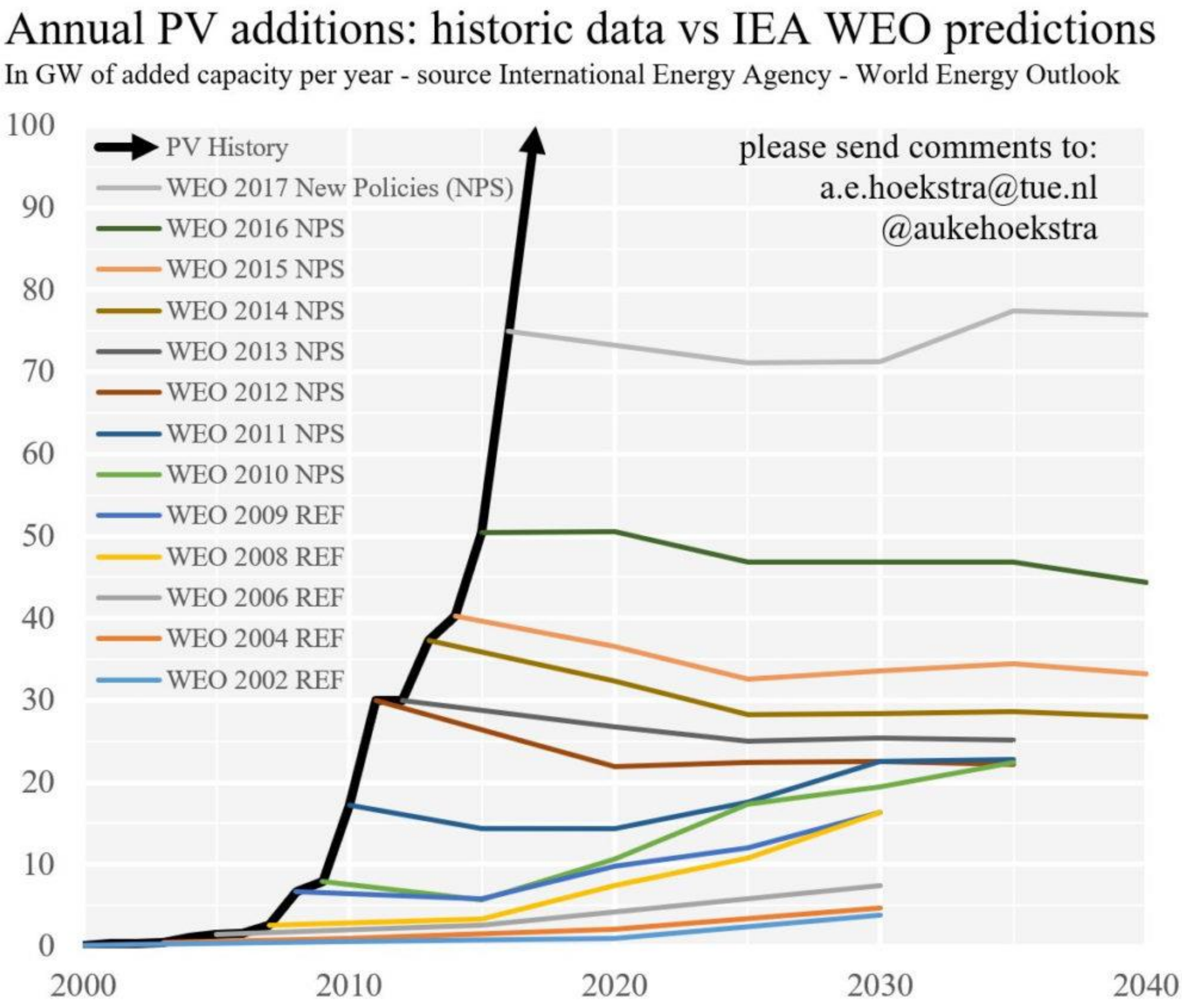
Mon 25 Mar 2019 11.00 GMT

Around 75% of coal production is more expensive than renewables, with industry out-competed on cost by 2025



Source: Energy Innovation, 2019 https://energyinnovation.org/wp-content/uploads/2019/03/Coal-Cost-Crossover_Energy-Innovation_VCE_FINAL.pdf

Real Photovoltaics Development vs. IEA Projections



Graphik: https://www.pv-magazine.de/2017/12/01

nature energy

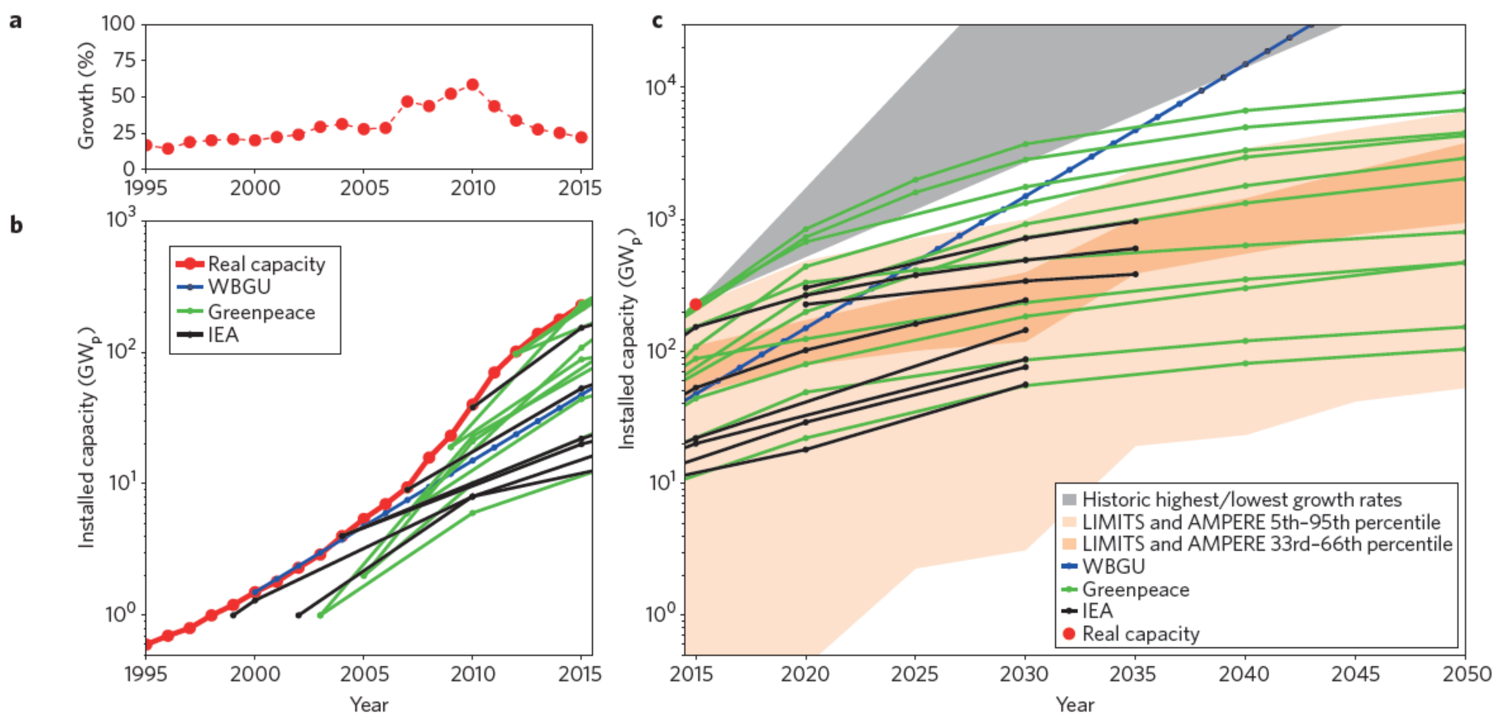
PERSPECTIVE

PUBLISHED: 25 AUGUST 2017 | VOLUME: 2 | ARTICLE NUMBER: 17140

The underestimated potential of solar energy to mitigate climate change

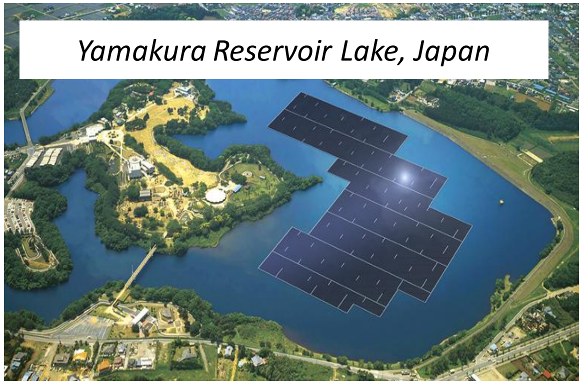
Felix Creutzig[1,2]*, Peter Agoston[1], Jan Christoph Goldschmidt[3], Gunnar Luderer[4], Gregory Nemet[1,5] and Robert C. Pietzcker[4]

The Intergovernmental Panel on Climate Change's fifth assessment report emphasizes the importance of bioenergy and carbon capture and storage for achieving climate goals, but it does not identify solar energy as a strategically important technology option. That is surprising given the strong growth, large resource, and low environmental footprint of photovoltaics (PV). Here we explore how models have consistently underestimated PV deployment and identify the reasons for underlying bias in models. Our analysis reveals that rapid technological learning and technology-specific policy support were crucial to PV deployment in the past, but that future success will depend on adequate financing instruments and the management of system integration. We propose that with coordinated advances in multiple components of the energy system, PV could supply 30–50% of electricity in competitive markets.



Growth in PV capacity and scenario projections.

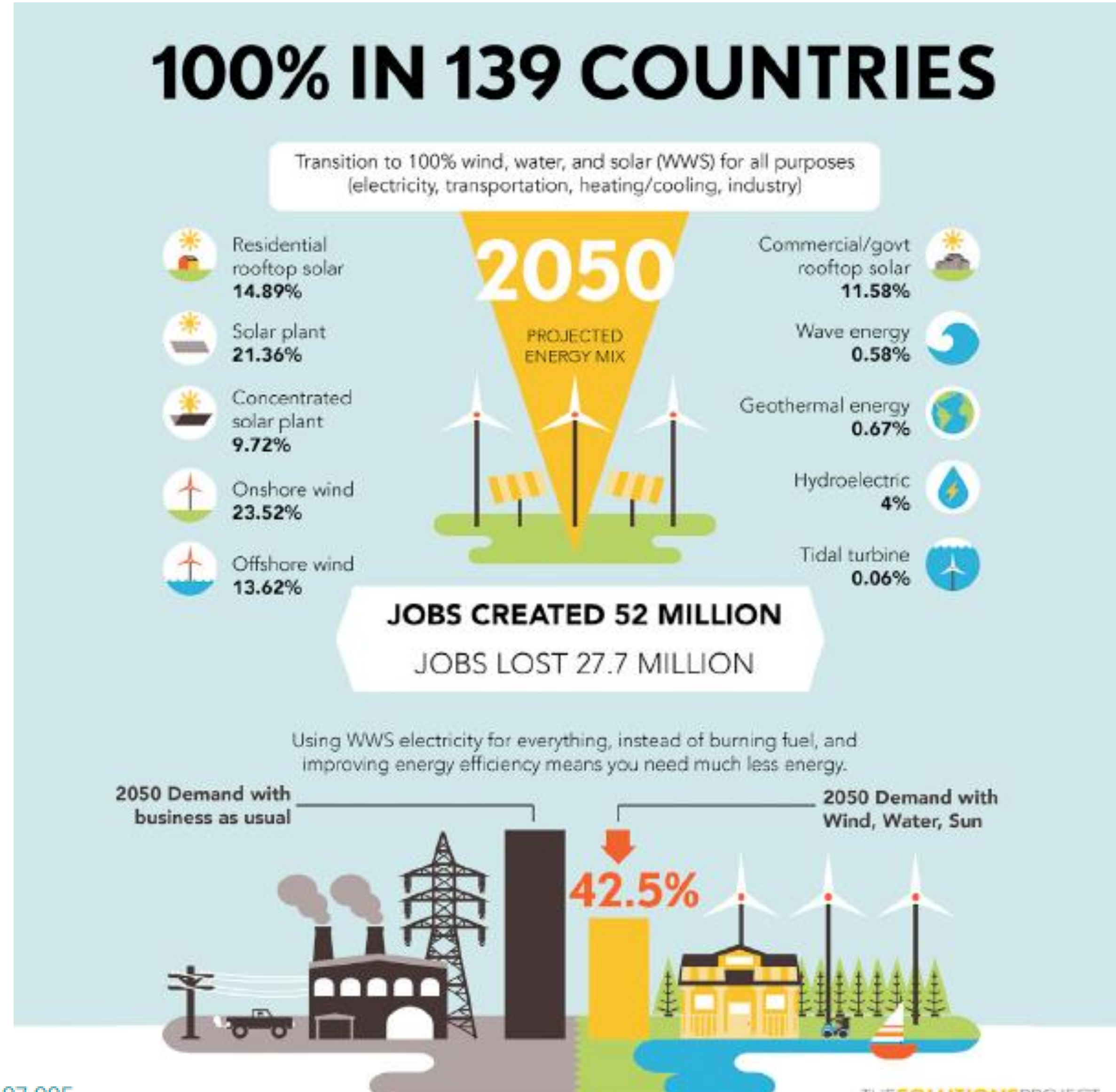
The Future of Solar Energy: Worldwide Innovation Projects



Article

100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World

Mark Z. Jacobson,[1,5,*] Mark A. Delucchi,[2] Zack A.F. Bauer,[1] Savannah C. Goodman,[1] William E. Chapman,[1] Mary A. Cameron,[1] Cedric Bozonnat,[1] Liat Chobadi,[3] Hailey A. Clonts,[1] Peter Enevoldsen,[4] Jenny R. Erwin,[1] Simone N. Fobi,[1] Owen K. Goldstrom,[1] Eleanor M. Hennessy,[1] Jingyi Liu,[1] Jonathan Lo,[1] Clayton B. Meyer,[1] Sean B. Morris,[1] Kevin R. Moy,[1] Patrick L. O'Neill,[1] Ivalin Petkov,[1] Stephanie Redfern,[1] Robin Schucker,[1] Michael A. Sontag,[1] Jingfan Wang,[1] Eric Weiner,[1] and Alexander S. Yachanin[1]



Joule

http://dx.doi.org/10.1016/j.joule.2017.07.005

European Commission

FINAL REPORT

of the High-Level Panel of the European Decarbonisation Pathways Initiative

Research and Innovation

High-Level Panel of the European Decarbonisation Pathways Initiative (HLP-EDPI)

Transition Super-Labs!!!

EU Commissi
Carlo

-EDPI
chellnhuber

Thimann

Catia Bastioli

Paul Ekins

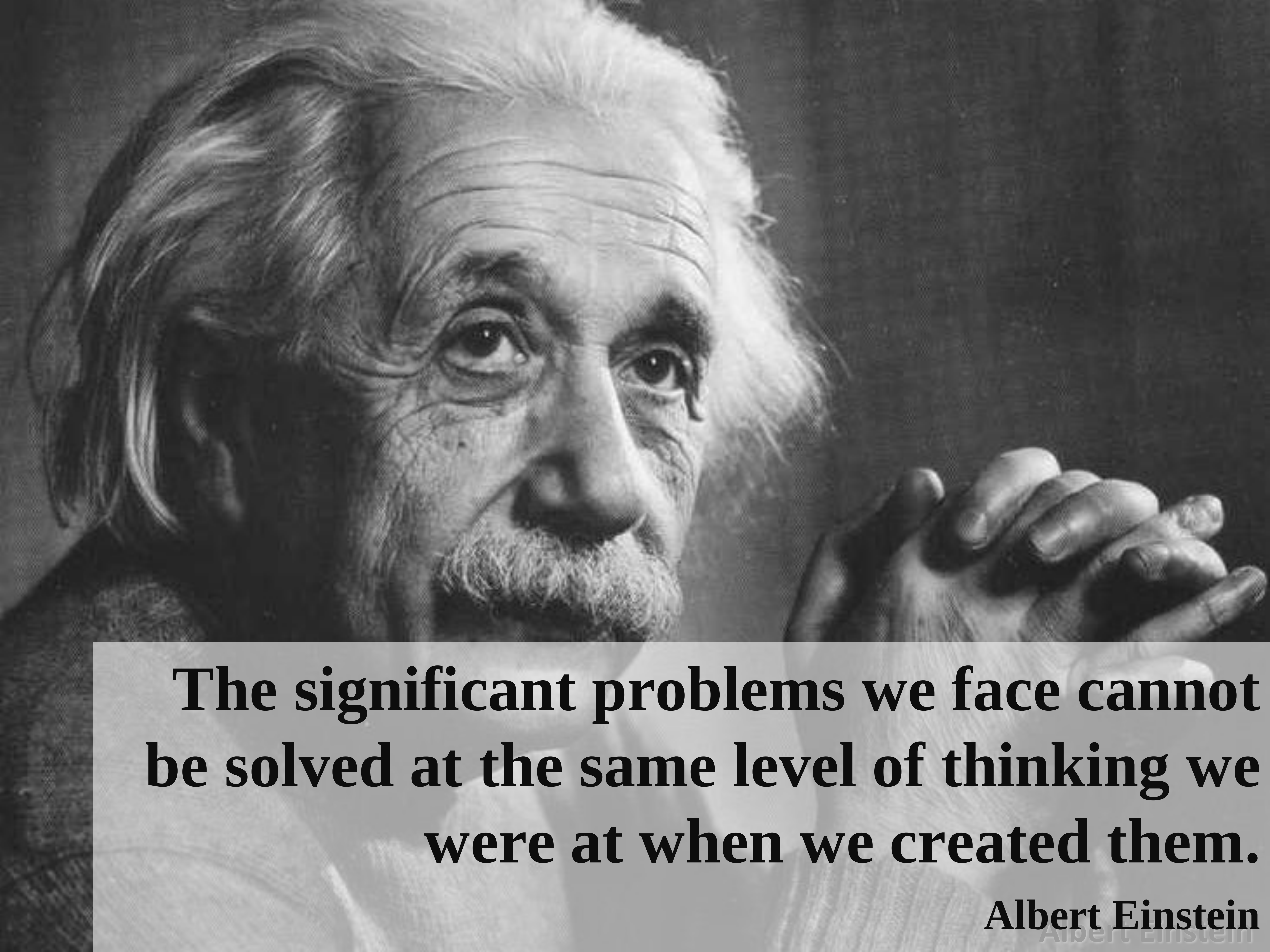
Beata Jaczewska

Barbara Kux

Laurence Tubiana

Maria van der Hoeven

Karin Wanngard


The significant problems we face cannot be solved at the same level of thinking we were at when we created them.
Albert Einstein

Towards Deep Machine Learning

Proc. Natl. Acad. Sci. USA
Vol. 79, pp. 2554–2558, April 1982
Biophysics

J.J. Hopfield, *PNAS, 1982*

Neural networks and physical systems with emergent collective computational abilities

(associative memory/parallel processing/categorization/content-addressable memory/fail-soft devices)

J. J. Hopfield

Division of Chemistry and Biology, California Institute of Technology, Pasadena, California 91125; and Bell Laboratories, Murray Hill, New Jersey 07974

Contributed by John J. Hopfield, January 15, 1982

ABSTRACT Computational properties of use to biological or ganisms or to the construction of computers can emerge as co lective properties of systems having a large number of simpl equivalent components (or neurons). The physical meaning of con tent-addressable memory is described by an appropriate phas space flow of the state of a system. A model of such a system i given, based on aspects of neurobiology but readily adapted to in tegrated circuits. The collective properties of this model produc a content-addressable memory which correctly yields an entir memory from any subpart of sufficient size. The algorithm for th time evolution of the state of the system is based on asynchronou parallel processing. Additional emergent collective properties in clude some capacity for generalization, familiarity recognition categorization, error correction, and time sequence retention The collective properties are only weakly sensitive to details of th modeling or the failure of individual devices.

Spin-glass models of neural networks,
Amit, Gutfreund and Sompolinsky
Phys. Rev. A, 1985

PHYSICAL REVIEW A VOLUME 32, NUMBER 2 AUGUST 1985

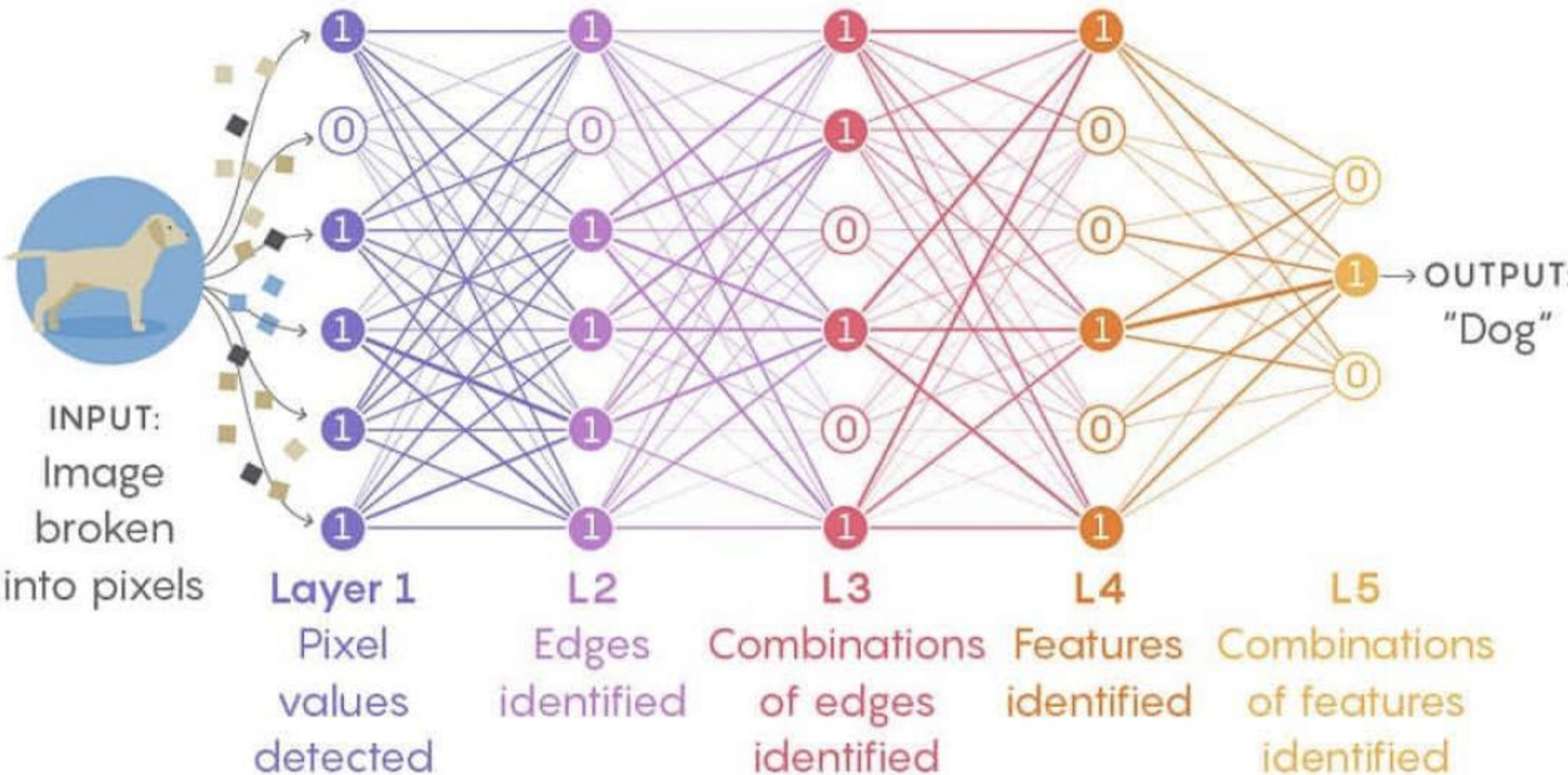
Spin-glass models of neural networks

Daniel J. Amit and Hanoch Gutfreund
Racah Institute of Physics, Hebrew University, 91904 Jerusalem, Israel

H. Sompolinsky
Department of Physics, Bar-Ilan University, 52100 Ramat-Gan, Israel

(Received 22 March 1985)

Two dynamical models, proposed by Hopfield and Little to account for the collective behavior of neural networks, are analyzed. The long-time behavior of these models is governed by the statistical mechanics of infinite-range Ising spin-glass Hamiltonians. Certain configurations of the spin system, chosen at random, which serve as memories, are stored in the quenched random couplings. The present analysis is restricted to the case of a finite number p of memorized spin configurations, in the thermodynamic limit. We show that the long-time behavior of the two models is identical, for all temperatures below a transition temperature T_c. The structure of the stable and metastable states is displayed. Below T_c, these systems have $2p$ ground states of the Mattis type: Each one of them is fully correlated with one of the stored patterns. Below $T \sim 0.46T_c$, additional dynamically stable states appear. These metastable states correspond to specific mixings of the embedded patterns. The thermodynamic and dynamic properties of the system in the cases of more general distributions of random memories are discussed.



Source: https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/

nature
International journal of science

Mastering the game of Go without human knowledge

David Silver[1]*, Julian Schrittwieser[1]*, Karen Simonyan[1]*, Ioannis Antonoglou[1], Aja Huang[1], Arthur Guez[1], Thomas Hubert[1], Lucas Baker[1], Matthew Lai[1], Adrian Bolton[1], Yutian Chen[1], Timothy Lillicrap[1], Fan Hui[1], Laurent Sifre[1], George van den Driessche[1], Thore Graepel[1] & Demis Hassabis[1]

A long-standing goal of artificial intelligence is an algorithm that learns, *tabula rasa*, superhuman proficiency in challenging domains. Recently, AlphaGo became the first program to defeat a world champion in the game of Go. The tree search in AlphaGo evaluated positions and selected moves using deep neural networks. These neural networks were trained by supervised learning from human expert moves, and by reinforcement learning from self-play. Here we introduce an algorithm based solely on reinforcement learning, without human data, guidance or domain knowledge beyond game rules. AlphaGo becomes its own teacher: a neural network is trained to predict AlphaGo's own move selections and also the winner of AlphaGo's games. This neural network improves the strength of the tree search, resulting in higher quality move selection and stronger self-play in the next iteration. Starting *tabula rasa*, our new program AlphaGo Zero achieved superhuman performance, winning 100–0 against the previously published, champion-defeating AlphaGo.

Source: Silver et. al 2017

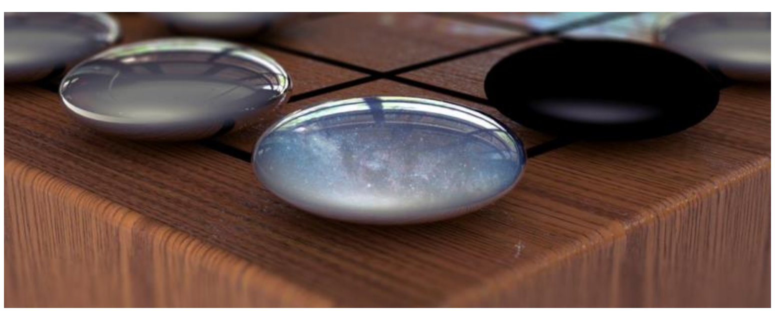


Image: DeepMind Technologies Ltd

The Telegraph 18 OCTOBER 2017

AlphaGo Zero: Google DeepMind supercomputer learns 3,000 years of human knowledge in 40 days

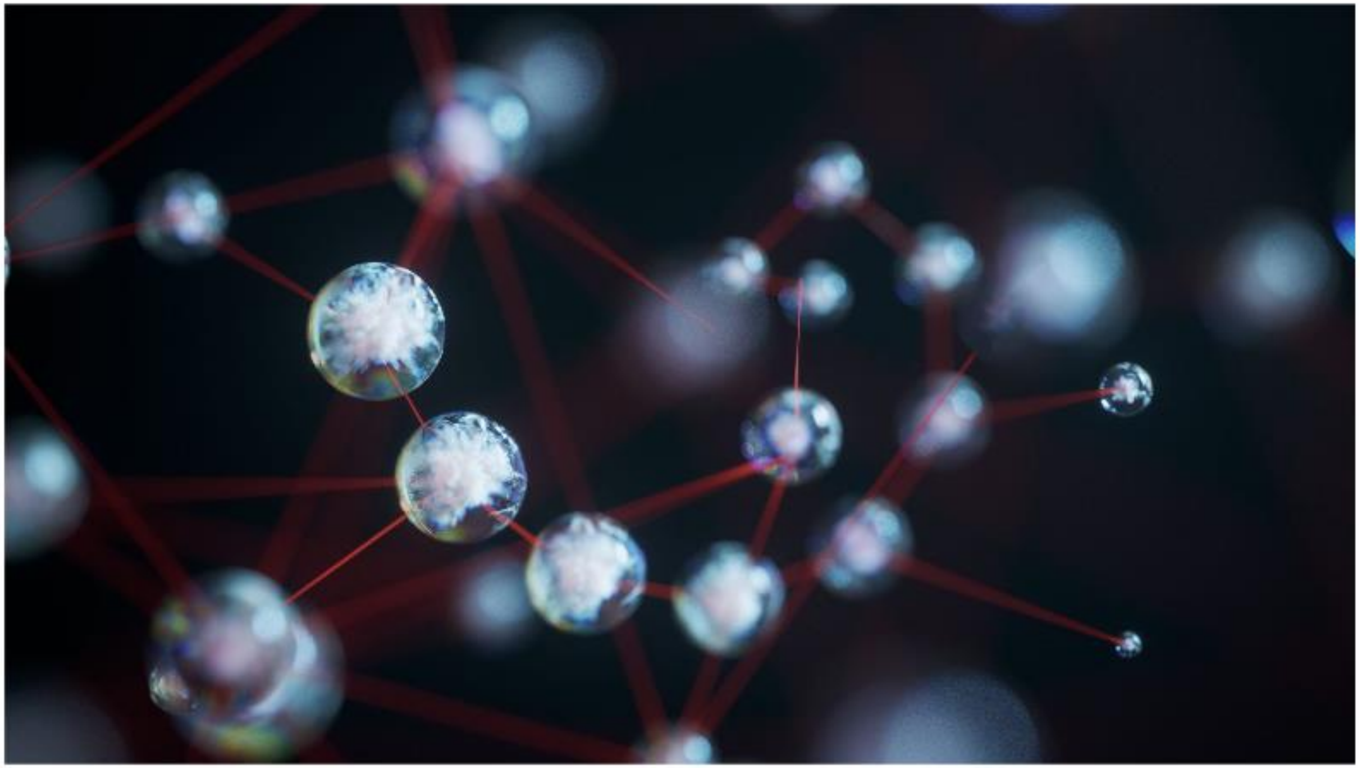
Fusion of Neural Networks and Quantum Computing

Quanta magazine

By George Musser

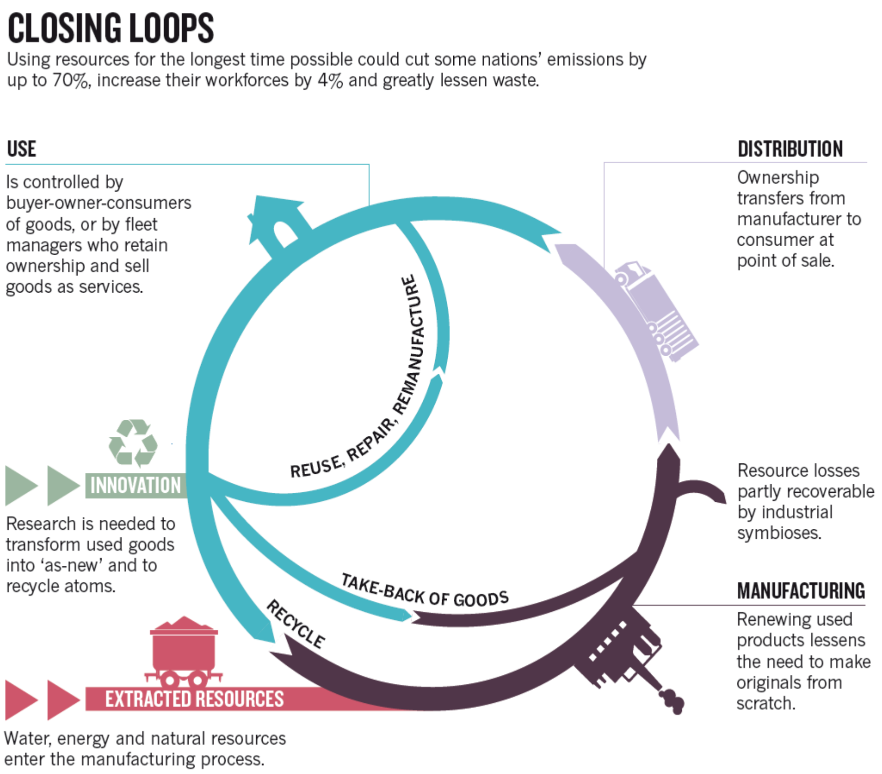
Job One for Quantum Computers: Boost Artificial Intelligence

The fusion of quantum computing and machine learning has become a booming research area. Can it possibly live up to its high expectations?



www.quantamagazine.org

The Dream of a Digital Circular Economy



(Stahel, 2016)

- **3-D Printing**
- **The Internet of Things**
- **Automation of Production**
- **Automation of Deconstruction**

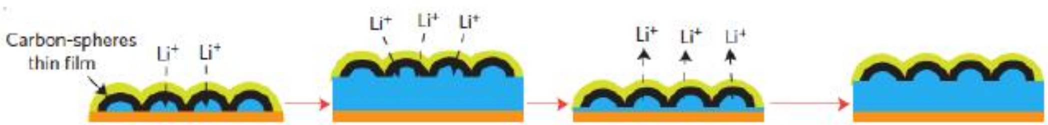
➔ **More Efficiency**

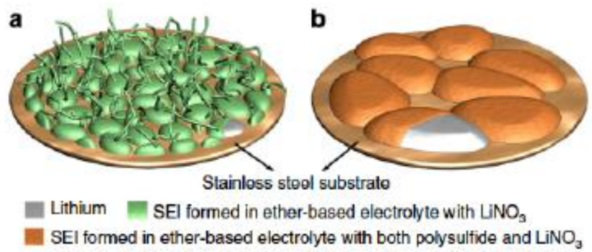
➔ **Less Material and Energy Usage**

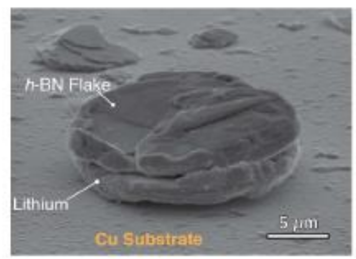
➔ **Better Monitoring of Material Flows**

Li Metal Anode: Holy Grail of Batteries

Materials for a Stable Interface

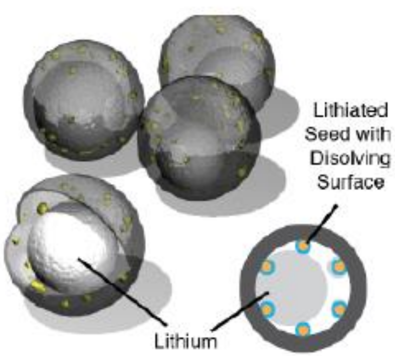


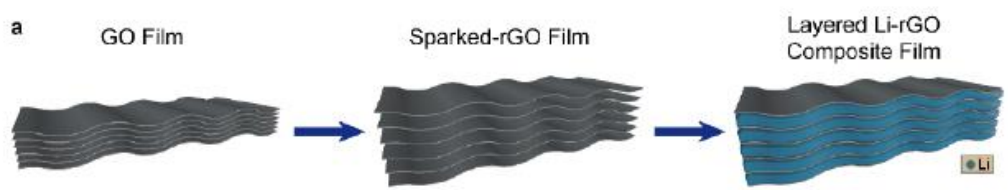




Prof. Steven Chu

Materials for a Stable Host





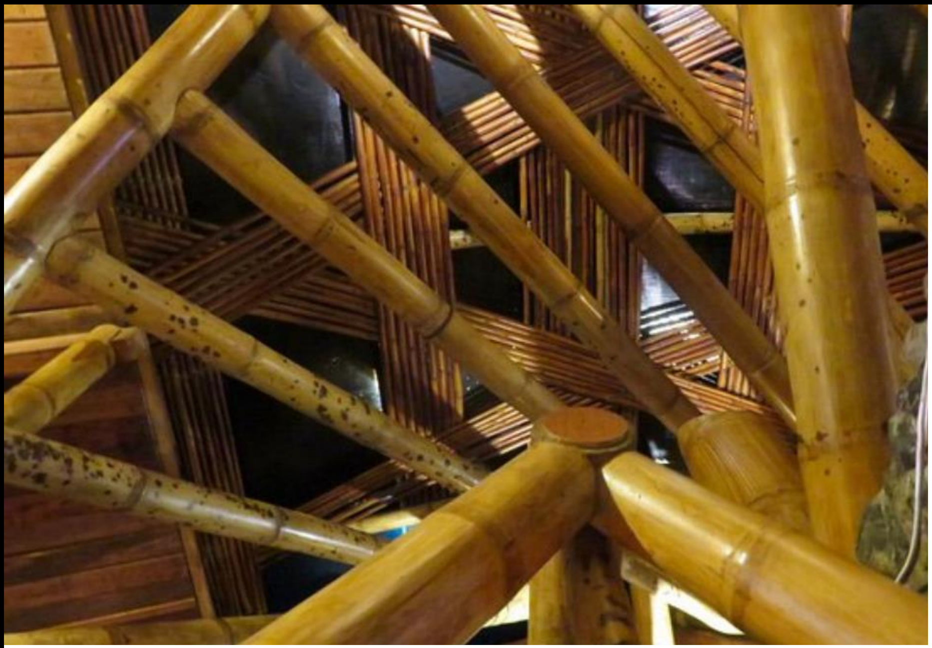
Source: Zheng et al. 2014

Costing the Earth: Construction and Concrete

© Omar Chatriwala/flickr

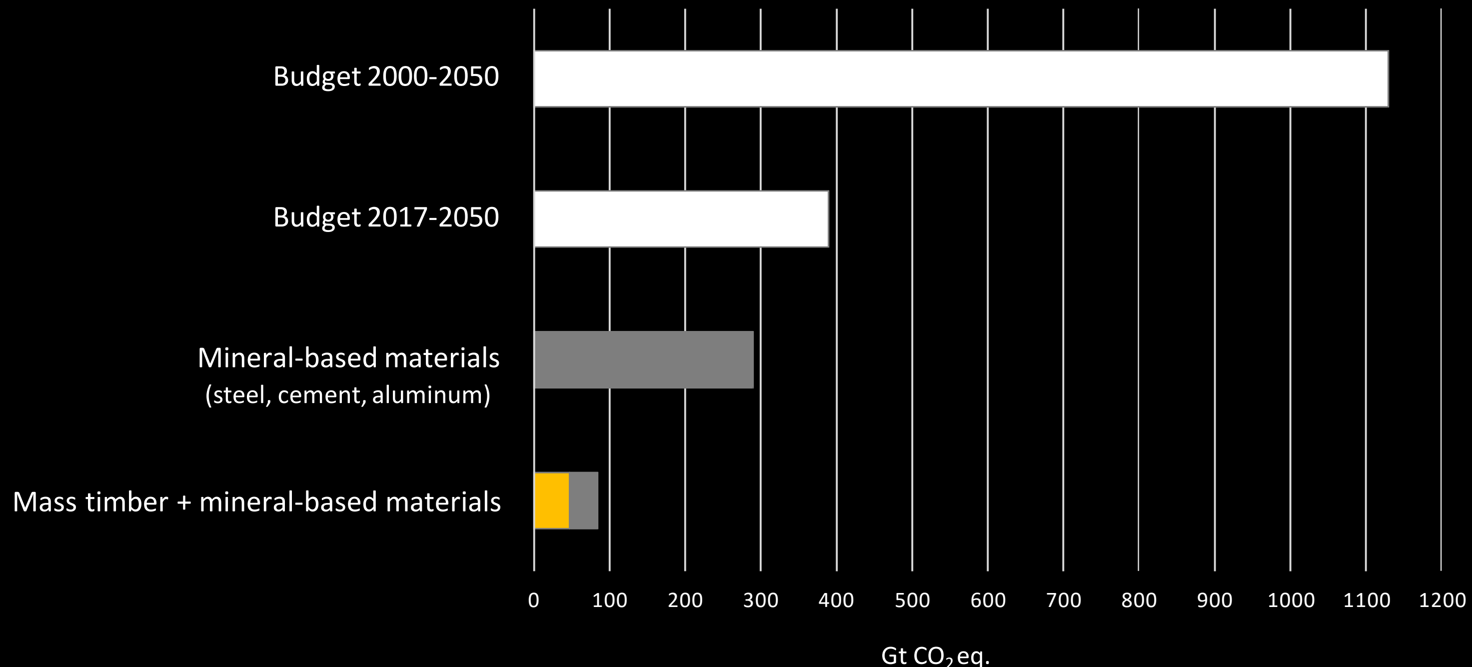
- Global construction until 2050 will require the same amount of infrastructure as has been built since 1850.
- This will use up most of the CO_2 budget (1.5°C), if conventional materials like concrete are used.
- In China alone more cement was used from 2008–2010 than during the entire 20th century in the USA.

→ **Climate change mitigation will be decided in the cities.**



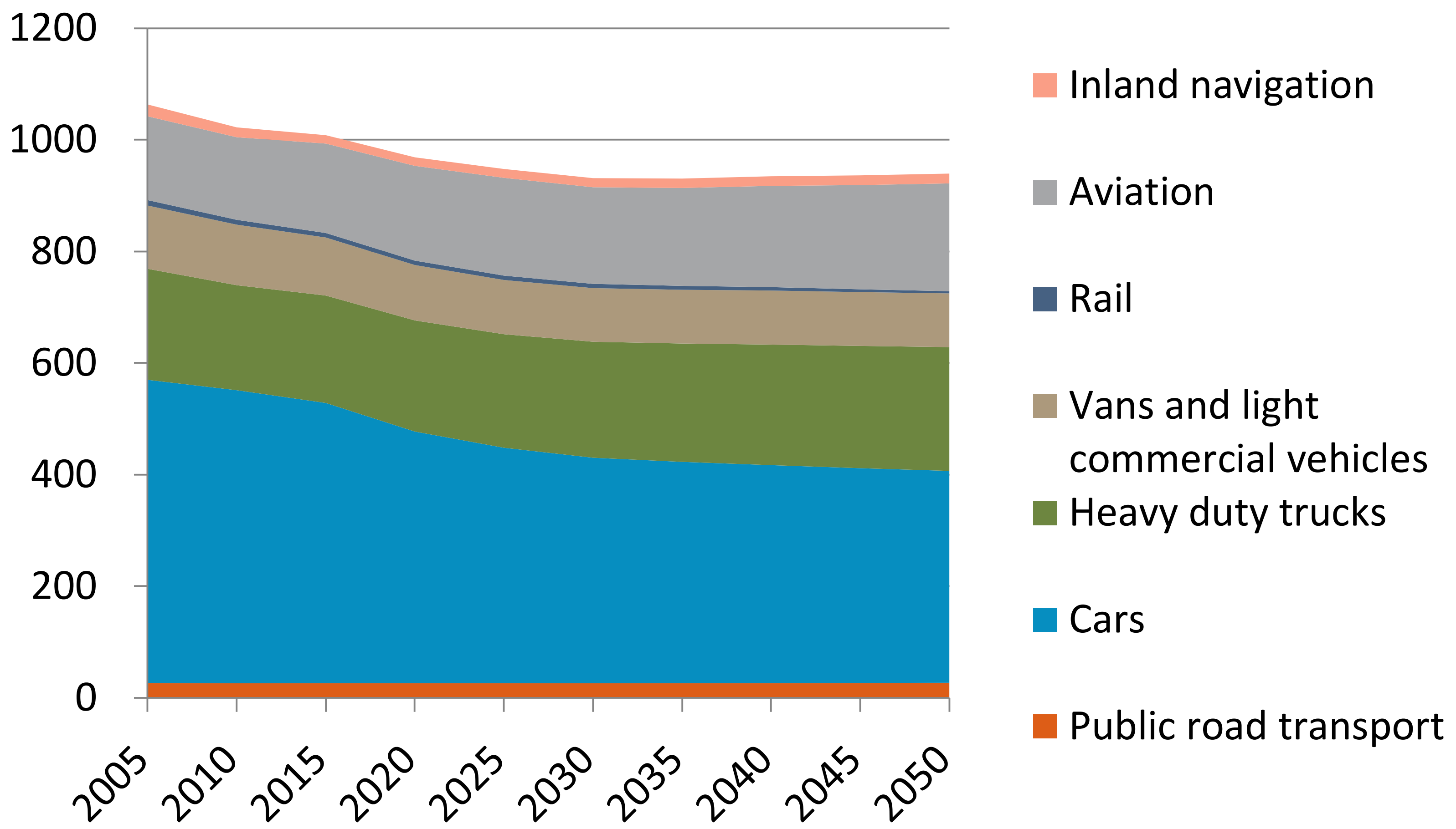
Biomass-based Materials in Construction

Greenhouse Gas Emissions (Gt CO_2 eq.)



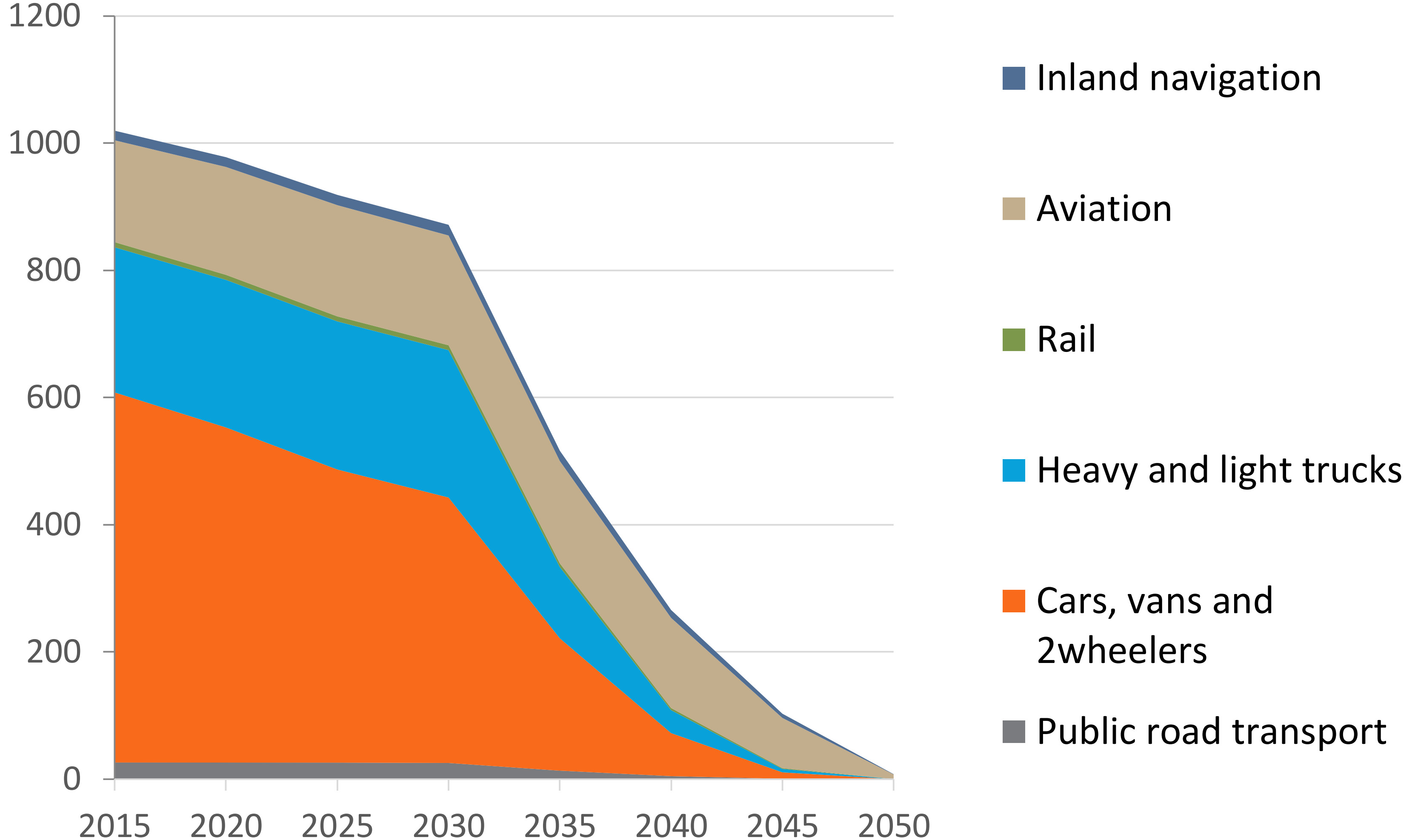
IPCC 2014, Olivier et al. 2017, Müller et al. 2013

Evolution of EU-28 national CO_2 emissions until 2050 by mode in the Reference scenario 2016



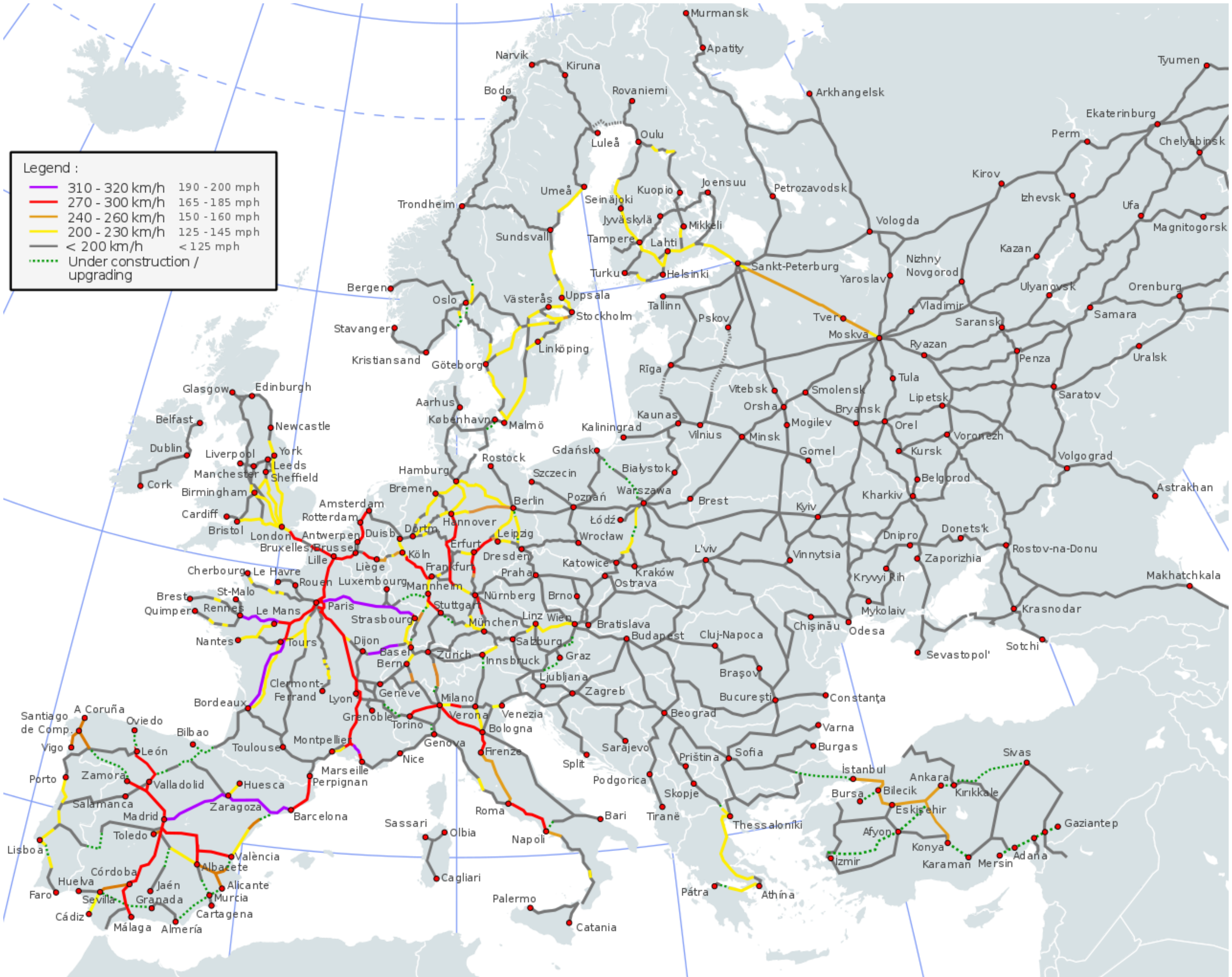
Source: Final Report, High-Level Panel of the European Decarbonisation Pathways Initiative, 2018

Evolution of the EU-28 transport sector CO_2 emissions in a 100% transport decarbonisation scenario



Source: Final Report, High-Level Panel of the European Decarbonisation Pathways Initiative, 2018

The European High-Speed Train Network: A Patchwork Rug!



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