Disruptive technologies and sustainable lifestyles toward net-zero emissions

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Four Great Achievements since the Beginning of Industrial Revolution

- Life expectancy has doubled in a century
- One billion are obese while less go hungry
- More die by suicide than war and violence
- Everyone in the world has a mobile phone
Mobile Phones Charging

Source: Modi, 2011
Collective Responsibility in the Anthropocene
Global fossil CO₂ emissions have risen steadily over the last decades. The peak in global emissions is not yet in sight.

Estimates for 2015, 2016 and 2017 are preliminary; 2018 is a projection based on partial data.

Source: CDIAC; Le Quéré et al 2018; Global Carbon Budget 2018
The Kaya decomposition illustrates that relative decoupling of economic growth from CO₂ emissions is driven by improved energy intensity (Energy/GWP).
“Carbon Law”

Graph showing the decline of annual global CO₂ emissions from 2010 to 2100. The emissions are categorized into anthropogenic CO₂ emissions (gross), fossil fuel and industry, and land use and land-use change.
“Carbon Law”

Annual global CO$_2$ emissions (GtCO$_2$ yr$^{-1}$)

- **human carbon emissions**
- anthropogenic CO$_2$ emissions (gross)
- anthropogenic CO$_2$ removals
  - fossil fuel and industry
  - land use and land-use change
  - land use and land-use change

“Carbon Law”

- **Anthropogenic CO\textsubscript{2} emissions (gross)**:
  - Fossil fuel and industry
  - Land use and land-use change
  - Land use and land-use change

- **Anthropogenic CO\textsubscript{2} removals**:
  - Engineering CO\textsubscript{2} sink (BECCS)

“Carbon Law”

- Anthropogenic CO₂ emissions (gross)
  - Fossil fuel and industry
  - Land use and land-use change

- Anthropogenic CO₂ removals
  - Land use and land-use change
  - Engineering CO₂ sink (BECCS)

- Biosphere carbon sink
  - Land carbon sink
  - Ocean carbon sink

Rockström, Gaffney, Rogelj, Meinshausen, Nakicenovic, Schellnhuber. Science 24 March 2017
The IPCC Special Report on “Global Warming of 1.5°C” presented new scenarios: 1.5°C scenarios require halving emissions by ~2030, net-zero by ~2050, and negative thereafter.

Net emissions include those from land-use change and bioenergy with CCS.
Source: Huppmann et al 2018; IAMC 1.5C Scenario Database; IPCC SR15; Global Carbon Budget 2018
Greenhouse gas emissions pathways

- To limit warming to 1.5°C, CO₂ emissions fall by about 45% by 2030 (from 2010 levels)
- To limit warming to 1.5°C, CO₂ emissions would need to reach ‘net zero’ around 2050
- Reducing non-CO₂ emissions would have direct and immediate health benefits

SDGs:
- Prosperity
- Social Inclusion
- Sustainability

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Sustainable Development Goals

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnerships for the Goals
Multiple Benefits of Integrated Policies

- Total Global Policy Costs (2010-2030)

- Only Energy Security
- Only Air Pollution and Health
- Only Climate Change

Source: McCollum et. al, 2012; IPCC, 2014
A GUIDE TO SDG INTERACTIONS: FROM SCIENCE TO IMPLEMENTATION

INTERNATIONAL COUNCIL FOR SCIENCE
Interactions between SDG 7 & other SDGs

Source: McCollum et. al, 2018
TWI2050 Report (www.TWI2050.org)

Key Messages

Synthesis

1. Framing and Introduction
2. The Challenges Ahead
3. Sustainable Development Pathways
4. Governing the Transformation

➢ >60 authors from ~20 organizations
➢ >150 contributors and participants
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TWI2050 Launch HLPF
11 July 2018, UN
Some Key Messages

- Attaining the SDGs in a resilient and lasting way, requires vigorous action now, and a people and planet focus beyond 2030!
- As everything is integrated in the connected world, the grand transformation requires a holistic perspective!
- Transformational change is needed but to succeed we must take along winners and losers!
- The world is at crossroads as we are currently experiencing signs of a counter-transformation!
- A central element of the sustainability transformation is effective and inclusive governance!
- Think globally, act locally! Think long-term, act now!
The World in 2050 (TWI2050.org)

“Doing More with Less” within Planetary Boundaries

Target space 2050+ →

Vision: Sustainable Future

One “backcasting” storyline and many transformational pathways

← Target space 2030

Transformation Diffusion

Legitimacy of BAU eroding
Six Major Transformations (TWI2050.org)

Digital revolution
Artificial intelligence, big data, biotech, nanotech, autonomous systems

Smart cities
Decent housing, mobility, sustainable infrastructure, pollution

Food, biosphere & water
Sustainable intensification, biodiversity, forests, oceans, healthy diets, nutrients

Human capacity & demography
Education, health, ageing, labor markets, gender, inequalities

Consumption & production
Resource use, circular economy, sufficiency, pollution

Decarbonization & energy
Energy access, efficiency, electrification, decent services

SDGs:
Prosperity, Social Inclusion, Sustainability

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www.twi2050.org
Global Primary Energy
Zero Emissions by 2050

Savings
Other renewables
Nuclear
Gas
Oil
Coal
Biomass

Energy Efficiency and Behavior
~50% Improvement by 2030
~50% REN by 2030

≈ 1.5°C
→ immediate Peak

Source: Sterner et al. 2016 after WBGU, 2015

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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%
Hydraulic Electricity Storage

Source: Eduard Heindl
NET Power Breaks Ground on Demonstration Plant for Oxyfuel, Natural Gas ZEP, La Porte, Texas

**THE ALLAM CYCLE**
Global Primary Energy

ALPS Low Energy Demand (LED)

Energy savings (efficiency, conservation, and behavior)
~55% improvement by 2030
~20% renewables by 2030

≈ 1.5°C → “Adjusted” Peak

Source: After Grubler et al, 2018
Impact of IC Technology Convergence

Source: Grubler et al., 2018
Impact of Digital Technology

Technology Diffusion Compared
digital revolution

Source: Nokia Bell Labs, 2017
Social and Technological Learning

The coming flood of data in autonomous vehicles

- RADAR: ~10-100 KB per second
- SONAR: ~10-100 KB per second
- GPS: ~50 KB per second
- CAMERAS: ~20-40 MB per second
- LIDAR: ~10-70 MB per second

Autonomous vehicles: 4,000 GB per day... each day

Source: Intel
“Autonomous” Feature of Tesla S
Darum geht zu allen Völkern [...] und lehrt sie alles zu befolgen was ich Euch geboten habe. Seid gewiss: Ich bin bei euch alle Tage bis ans Ende der Welt.
Pipistrel electric aircarft

Source: Ivo Boscarol
Urban mobility FRA airport
Progress Eagle
ありがとうございます