Transitions to Low-Carbon Economy

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Fordham University Law School – 20 September 2017
Transitions to Low-Carbon Economy & How to Finance it

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A GLOBAL RESEARCH INSTITUTE

- Established as a scientific bridge between East and West
- After Cold War ended focused on multiple dimensions of global change
- Now embarked on the new research strategy for the next decade
International, independent, interdisciplinary science

research & big-data on major global problems

Solution & policy oriented, integrated systems analysis
| 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
Global Transformations

Years before present

People

10^11
10^10
10^9
10^8
10^7
10^6

10^6 10^5 10^4 10^3 10^2 10^1 10^0

Hunter-Gatherer

Source: Kates, 1997; Deevey, 1960
Global Transformations
Neolithic Revolution

Years before present

10^11
10^10
10^9
10^8
10^7
10^6

People

10^6 10^5 10^4 10^3 10^2 10^1 10^0

700 Million → 1700 A.D.
7 Million → 5000 B.C.

Neolithic
Hunter-Gatherer

Source: Kates, 1997; Deevey, 1960
Global Transformations
Neolithic and Industrial Revolutions

Years before present

People

10^11
10^10
10^9
10^8
10^7
10^6

10^6 10^5 10^4 10^3 10^2 10^1 10^0

Neolithic
Hunter-Gatherer
Industrial

7 Million 5000 B.C.
700 Million 1700 A.D.
7,000 Million

Source: Kates, 1997; Deevey, 1960
Global Transformations

Anthropocene — Sustainability

Years before present

after present

People

10^{11}

10^{10}

10^{9}

10^{8}

10^{7}

10^{6}

10^{5}

10^{4}

10^{3}

10^{2}

10^{1}

10^{0}

10^{1}

10^{2}

10^{3}

10^{4}

10^{5}

10^{6}

10^{7}

10^{8}

10^{9}

10^{10}

10^{11}

Hunter-Gatherer

Neolithic

Industrial

1700 A.D.

5000 B.C.

7 Million

700 Million

7,000 Million

12.5 Billion

5 Billion

Source: Lutz & Scherbov, 2007; 2008
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 Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

1400 Million motor vehicles
1200
1000
800
600
400
200
0
1750 1800 1850 1900 1950 2010

Transportation

Source: Steffen et al. 2015
The Great Acceleration

7 Billion phone subscriptions

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
The Great Acceleration

390 Atmospheric conc., ppm

360

330

300

0

1750 1800 1850 1900 1950 2010

Carbon dioxide

Source: Steffen et al. 2015
The Great Acceleration

Source: Steffen et al. 2015
Possible Unified Analytical Approach

Proximate Drivers
- Population
- Economy
- Technology
- Governance

Ultimate Drivers
- Values and Needs
- Knowledge and Understanding
- Power Structure
- Culture

Scenario Narratives
Integrated Models

Source: Paul Raskin, 2002
Urbanization World

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Source: Grubler et al. 2012

IIASA SRES A2r scenario
IIASA SRES B1 scenario
IIASA SRES B2 scenario

Historical (UN)

Population

Source: Grubler et al. 2012
Urbanization
World, UK, BRICs

Source: Grubler et al. 2012
Global Educational Attainment

Source: Lutz et al., 2007
Participatory Governance

Source: Modelski & Perry, 2008; 2010

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Population

0% 20% 40% 60% 80% 100%

1850 1900 1950 2000 2050 2100

Participatory
Participatory Governance

Slavery Abolishment

Source: Nakicenovic & Rogner, 2012;

1863 United States of America

1906 China

1948 UN Declaration of Human Rights

Population

1850 1900 1950 2000 2050 2100

0% 20% 40% 60% 80% 100%
Dimensions of Transformation

Source: Paul Raskin, 2002
IAM Models, Narratives and Scenarios

SSPs (Basic Drivers)

Narratives
- O’Neill et al.

GDP
- Dellink, Crespo, Leimbach et al.

POP
- KC & Lutz

Urbanization
- Jiang & O’Neill

Technology, Demand, Life-styles, Productivity

Energy

Land-use

GHG Emissions

Aerosol/Pollutant Emissions

Source: Riahi et.al, 2015
Global Emissions CO₂

Billion tons CO₂

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IPCC – RCPs – SSPs

New community scenarios for climate mitigation, adaptation, vulnerability and impacts assessments

MESSAGE (IIASA)
AIM (NIES)
GCAM (PNNL)
IMAGE (PBL)

Nakicenovic et al., 2011; van Vuuren et al., 2013; Jones et al., 2013
Sources of Uncertainty in Future Global Mean Temperature

Source: IPCC WGI, 2014
Global CO$_2$ Emissions
Global CO2 Emissions

IPCC Category I
RCP 2.6
1.5°C ≈ 2.0
1.5°C ≈ 2.0

Source: Rogelj et. al, 2015
Cumulative Emissions & Temperature

Cumulative total anthropogenic CO₂ emissions from 1870 (GtCO₂)

Temperature anomaly relative to 1861-1880 (°C)

Source: IPCC WGI, 2013
Urban Embodied Emissions Compared to Global Budget of 800 GtCO₂ for 2°C

Source: Müller et al., 2013

Possible emissions from future stock growth (350 Gt)
Net-negative CO₂ Emissions

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

NO Scenarios with net negative Emissions above ~ 2.8 degree

NO Scenarios without net negative Emissions below ~ 1.5 degree
Global Primary Energy

Historical Evolution

- Other renewables
- Nuclear
- Gas
- Oil
- Coal
- Biomass

- Dampfmaschine
- Ottomotor
- Vakuumröhre
- Fernseher
- Kommerzielle Luftfahrt
- Nuklearenergie
- Mikrochip
- Renewables Nuclear
- Gas
- Oil
- Coal
- Biomass

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2017 #47
Global Primary Energy
A Transformational Pathway

Energy savings (efficiency, conservation, and behavior)
~40% improvement by 2030
~30% renewables by 2030

Source: Riahi et al, 2012
Global Water Withdrawals
A Transformational Pathway

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Source: Fricko et al, 2014

2017 #49
Global Primärenergie

Energie Einsparungen (Effizienz, Umwandlung und Verhalten)
~50% Verbesserung bis 2030

~50% EE bis 2030

≈ 1.5°C
Multiple Benefits of Integrated Policies

Source: McCollum et. al, 2012; IPCC, 2014
2030 GEA Goals and Targets

● Universal Access to Modern Energy
● Double Energy Efficiency Improvement
● Double Renewable Share in Final Energy

Aspirational & Ambitious but Achievable
Interplay and the SDGs

• Fundamentally, there are two agendas embedded in the SDGs
  – We can call them (i) the human security agenda and (ii) the planetary boundaries agenda

• The challenge is to make these agendas synergistic rather than competitive
  – Consider the case of Africa and the issues of demographic trends and food security under the impacts of climate change
SDGs and their targets basis for the 2030 target space to be achieved from base-year

Second target space is 2050 and beyond for achieving sustainability for all and the planet

Backcasting storylines join target spaces in broad terms through transformational change

Model results and storyline interpretations result in sustainable development pathways
Vision: Sustainable Future

Growing number of actors of change:
- green businesses
- cities
- civil society
- science
- IGOs (UN etc.)

Transformation Diffusion

Legitimacy of BAU eroding → Growing number of actors of change

New values and norms

2030: Achievement of SDGs

2050: Sustainability transformation

Source: After WBGU, 2011

The World in 2050 (TWI2050.com)
The World in 2050 (TWI2050.com)

“Doing More with Less” within Planetary Boundaries

Vision: Sustainable Future

Target space 2050+ → Target space 2030

One “backcasting” storyline and many transformational pathways

Legitimacy of BAU eroding

Source: After WBGU, 2011

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2017 #57
UK – Replacement within Vehicle Fleets

Percent of vehicles

100
80
60
40
20
0

1900 1910 1920 1930 1950 1960 1970

Horse carriages & hackneys
Automobiles
Steam locomotives
Diesel/electric

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(Harmon, 1999)

$\text{Learning rate} = 19.7\%$

Module Price (1994/$W_p$)

Cumulative PV Module Shipments (MW)

Supply Technologies Cost Trends

Source: Grubler et al, 2012

230GW @ $0.8/W
Cumulative Experience and Learning

The Importance of “granularity”

Mean of “granular” end use technologies:
LR = 20%
CumProd = 10e9

Mean of “lumpy” supply technologies:
LR = 10%
CumProd = 10e4

Investment Portfolios World

No Sustainability Policies
(2558 bill.)

Today
(941 bill.)

2005-2010

2050

Oil
Gas
Coal
Electricity
Transmission
Renewable Electricity
Fossil Electricity
Electricity Transmission
Other conversion

Source: Riahi et al, 2012

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Investment Portfolios
World

No Sustainability Policies
(2558 bill.)

2005-2010

Today
(941 bill.)

2050

GEA-Efficiency
(2849 bill.)

Source: Riahi et al, 2012

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Vision of a Sailing Railway
Monorail using sails proposed by
Henry R. Palmer in 1828

Source: Marshall, 1938
THANK YOU

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