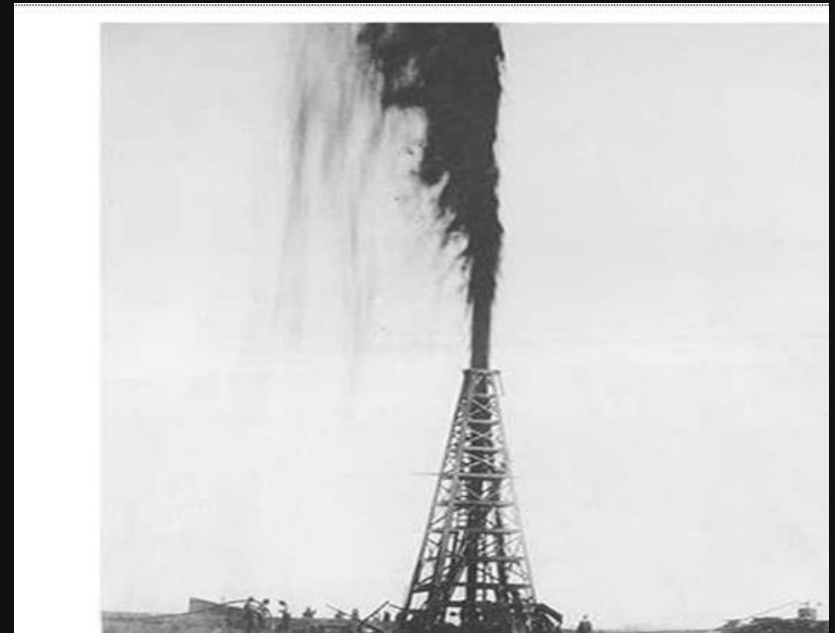


Energy and societal transformation processes

I. Energy and wealth production: a short historical perspective

II. Great Transformation processes



Energy and wealth production – a historical perspective

*...” the fates of past civilizations and other events of the past can be better understood from the perspective of the importance of energy, and in particular **surplus energy**”*

(Hall and Klitgaard 2012, p. 41)

I. Energy and wealth production

Pre-historic energy uses

Humans as energy-optimized beings

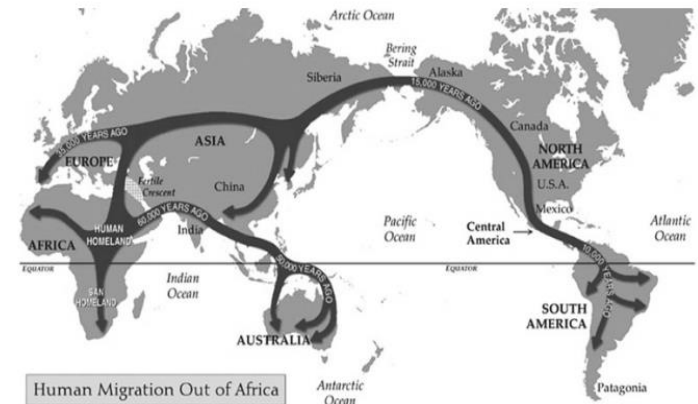
*“...humans use only $\frac{1}{4}$ as much energy **to walk** 100 meters than a chimpanzee does”* (Hall and Klitgaard, 2012; p. 45)

Humans searching for energy-concentrating solutions

Development of simple tools such as spear points and knives to focus the energy of a human arm on a given point or line

- new hunting schemes
- life in other (more hostile) environments possible

Source: Hall and Klitgaard, 2012



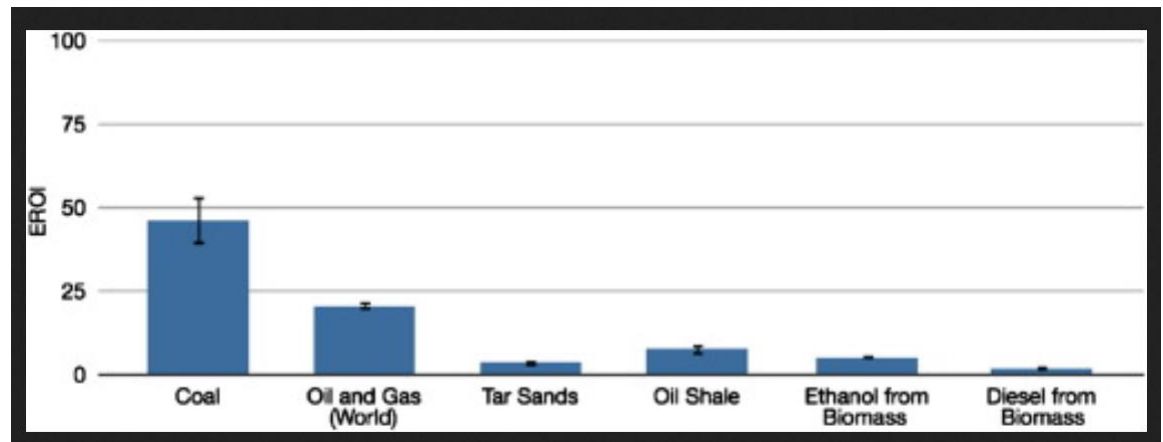
I. Energy and wealth production

Agriculture and energy

Migration explained through EROI

EROI = energy return / energy invested

Hunters-gatherers,
EROI \approx 10:1



Source: Hall et al., 2014

I. Energy and wealth production

Agriculture and energy

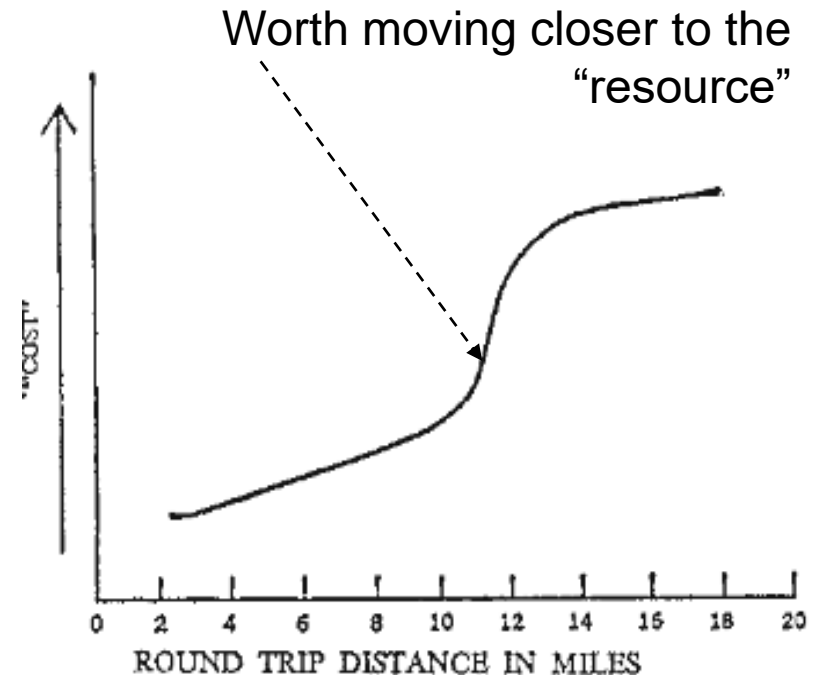
Migration explained through EROI

EROI = energy return / energy invested

Hunters-gatherers,
EROI \approx 10:1

But

- not controllable, unstable!
- cyclic processes of population increase and collapse



Source: Hall and Klitgaard, 2012

I. Energy and wealth production

Agriculture and energy

Consequences of agriculture

- Settled in one place: no migrations required!

I. Energy and wealth production

Agriculture and energy

Consequences of agriculture

- Settled in one place: no migrations required!
- Worsening average nutritional state: ...*"data indicate that the people actually became shorter and smaller with the advent of agriculture, indicating a decrease in nutritional quality. In fact the people of that region did not regain the stature of their hunter-gatherer ancestors until about the 1950s."* (Hall and Klitgaard, p.63)

I. Energy and wealth production

Agriculture and energy

Consequences of agriculture

- Settled in one place: no migrations required!
- Worsening average nutritional state
- Tremendous increase in **social stratification: specialization!!!** -
„Agricultural surpluses allowed a greater differentiation of labor and with it a greater difference in wages, status, and social power. This differentiation led in time to extreme differences in political power. This power was enhanced as professional military men became increasingly common“ (Hall, p.69)

I. Energy and wealth production

Agriculture and energy

Consequences of agriculture

- Settled in one place: no migrations required!
- Worsening average nutritional state
- Tremendous increase in social stratification: specialization!!!
- Wealth production and population increase...

I. Energy and wealth production

Agriculture, animal husbandry, metallurgy and energy

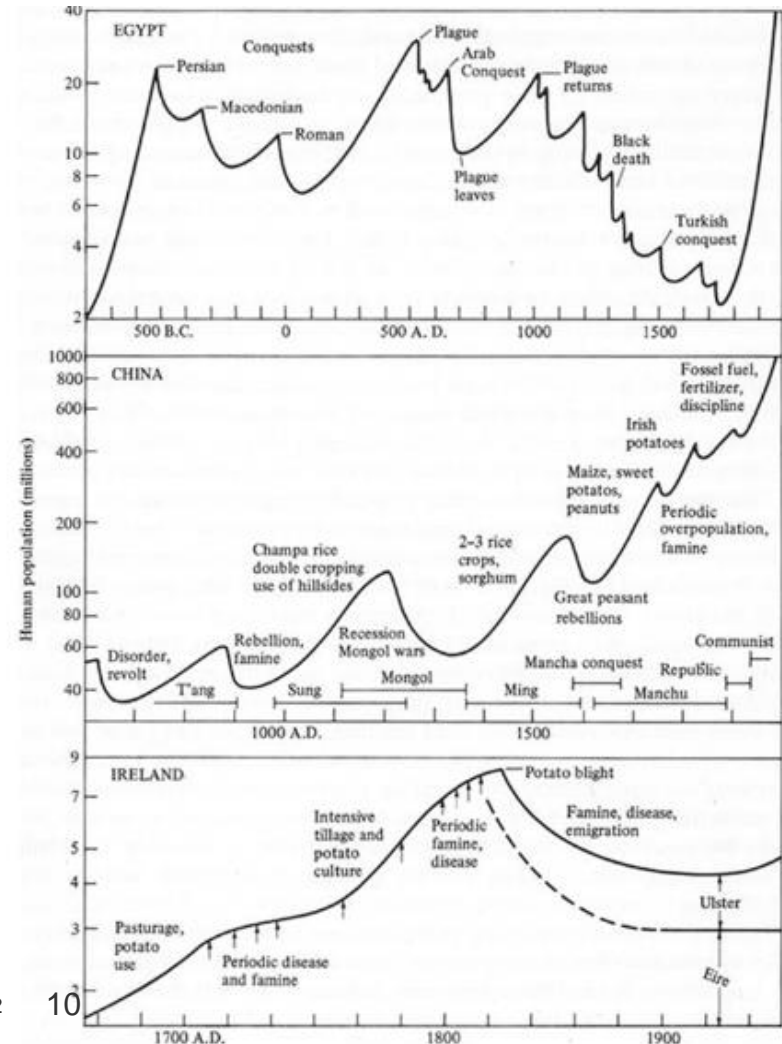
Cyclic collapse

- Settlement in ore-rich region
- Biomass use for metallurgic processes cleared land for agriculture
- Arts, crafts, specialized production: trade and wealth

→ Population increase

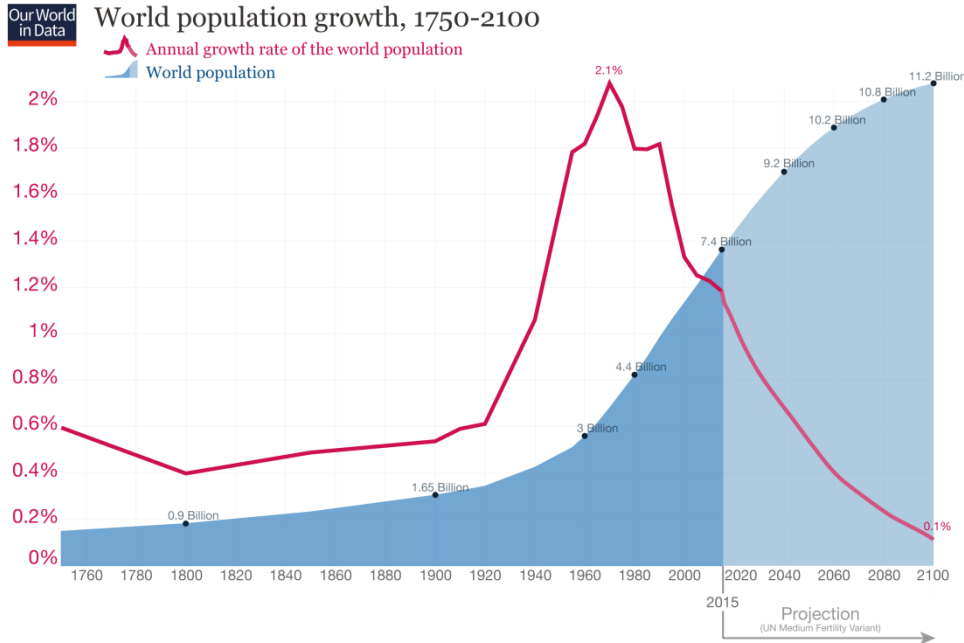
....

Ecological capacity reached: ore and land „depleted“ → collapse, population decrease



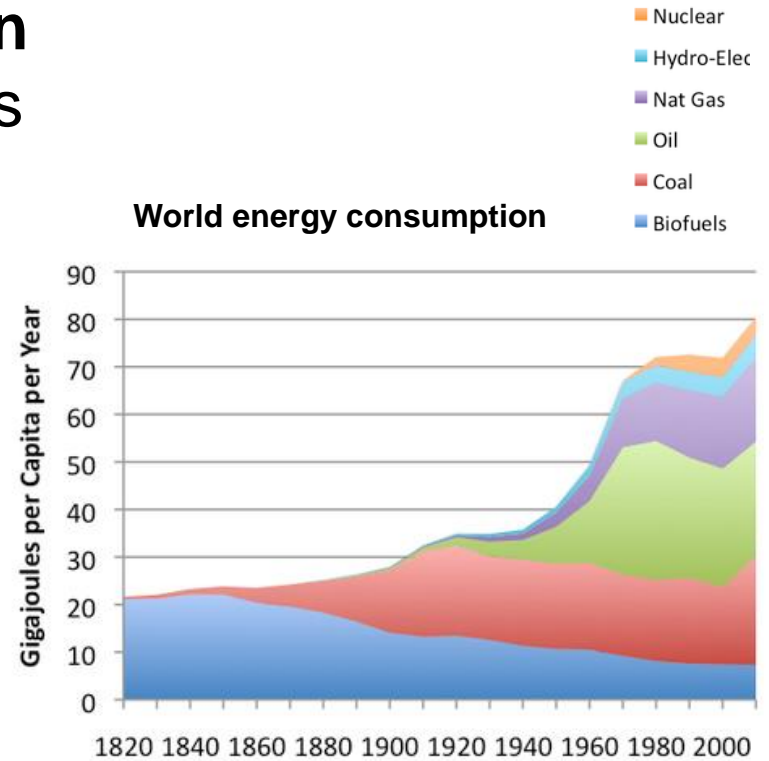
I. Energy and wealth production

From „solar“ to oil-based societies



Data sources: Up to 2015 OurWorldInData series based on UN and HYDE. Projections for 2015 to 2100: UN Population Division (2015) – Medium Variant. The data visualization is taken from OurWorldInData.org. There you find the raw data and more visualizations on this topic. Licensed under CC-BY-SA by the author Max Roser.

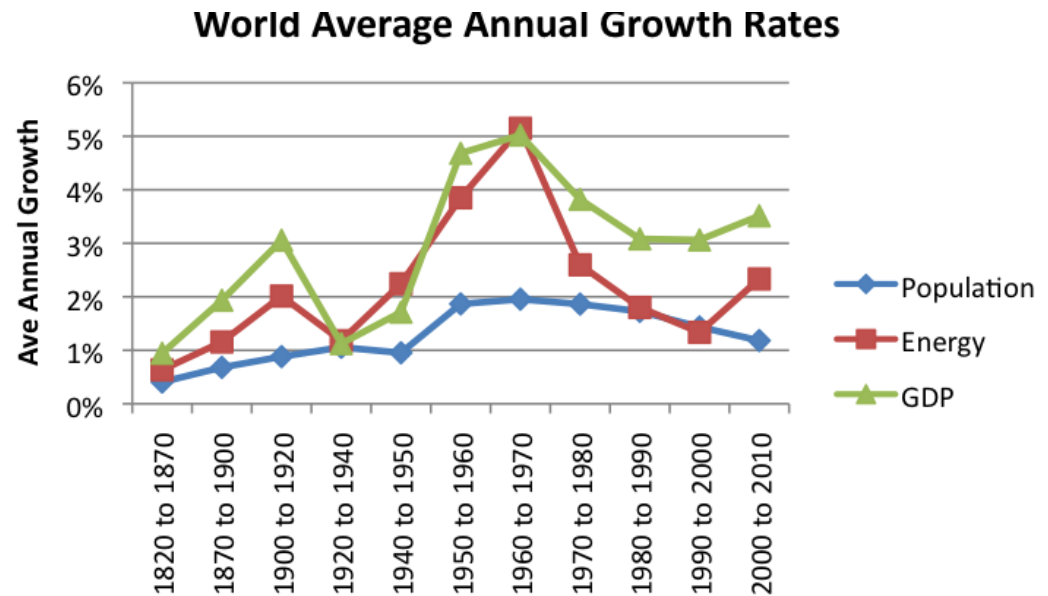
Source: Roser and Ortiz-Ospina, 2018



Source: <http://www.theoilrum.com/node/9023>

I. Energy and wealth production

Energy, wealth and population



Source: Tverberg 2012

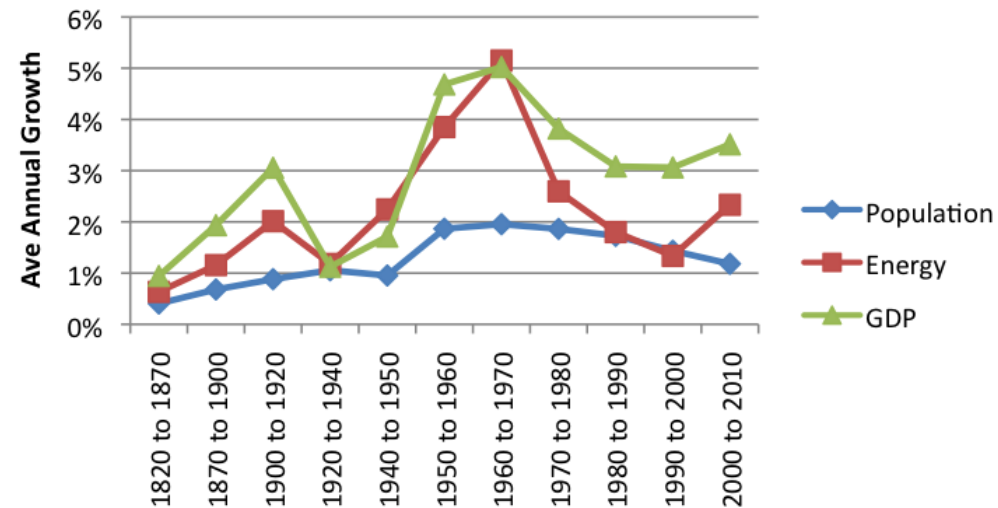
... "the main way that countries develop (i.e., get richer) is through using more energy to do more economical work " (Hall and Klitgaard, p. 89)

I. Energy and wealth production

From „solar” to oil-based societies....and forth*??

Using fossil fuels allowed unprecedented levels of population and GDP growth, highly specialized and services societies...

World Average Annual Growth Rates



Source: Tverberg 2012

-> Example: mobility transition in Germany!

Energy and societal transformation processes

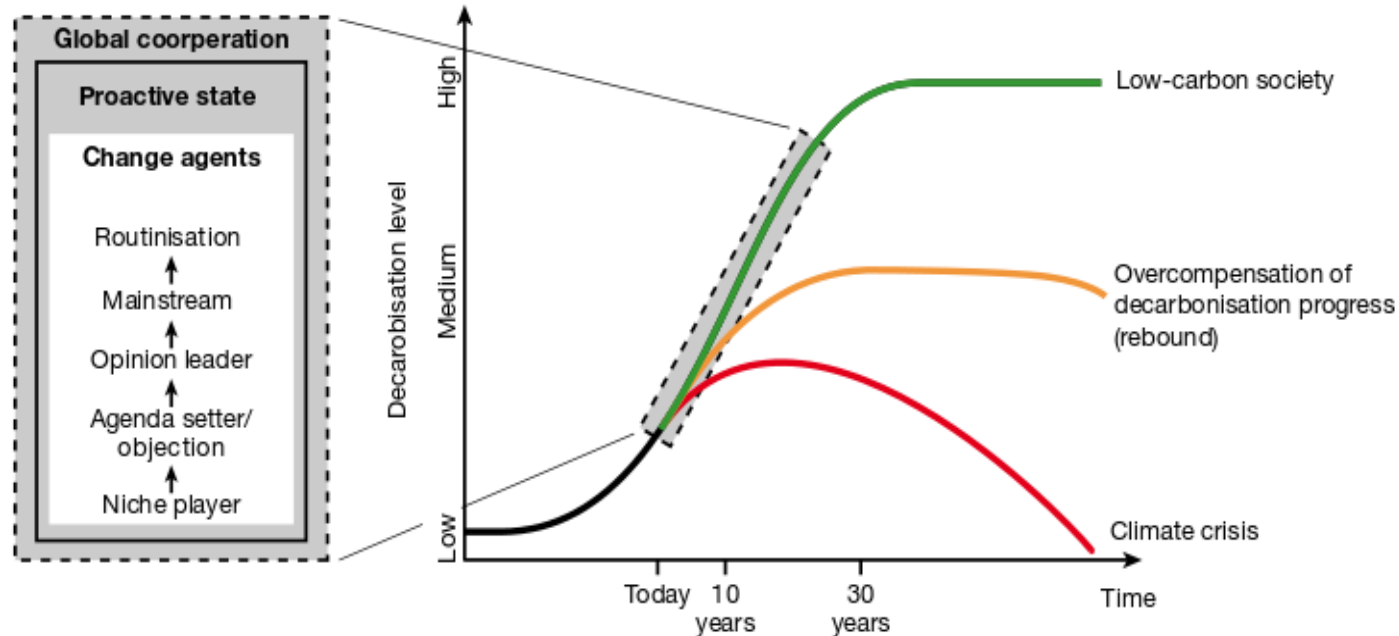
I. Energy and wealth production: a historical perspective

II. Great transformation processes

- a) historical review
- b) a look forward
- c) GT characteristics

II. The Mobility Transformation as a **great transformation**

Summary for Policy-Makers



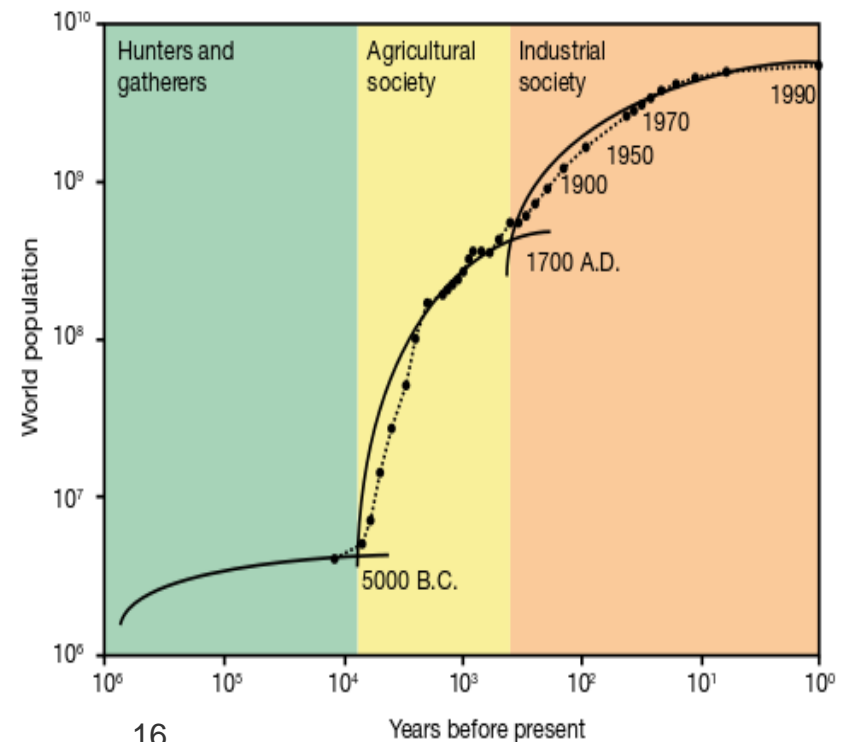
II. The Mobility Transformation as a **Great Transformation**

Other „**Great Transformations**“ in history:

- **Neolitical revolution**: from gatherers-hunterers to agriculture!
- **Industrial revolution**: fossil fuel use!

Hunters & gatherers	Agricultural society	Industrial society
Energy input [GJ/capita and year]		
→	→	→
10–20 Biomass (food, wood, ...)	ca. 65 Biomass 3 vegetarian food 50 feed production 12 wood	250 Different energy carriers 170 fossil energy 5 hydropower 14 nuclear power 61 biomass
Material input [t/capita and year]		
→	→	→
ca. 1 Biomass (food, wood, ...)	ca. 4 Biomass 0.5 vegetarian food 2.7 feed production (DS) 0.8 wood	19,5 Various materials 4.7 biomass (DS) 5.1 oil, coal, gas 9.7 minerals, metals, ...

Source: WBGU, 2011,



II. Great Transformation processes

Review: The Neolitical revolution

No uncontested theory on “why” it happened exists

- Change in climatic conditions as possible cause
- Leading to a worsening/improving availability of food
- Making possible sedentary societies and developing agriculture

But it is clear that it lead to:

- Unprecedented acceleration of social, cultural, technological and economic development
- More complex and differentiated (specialized) societies

II. Great Transformation processes

Review: The Neolitical revolution

Characteristics of agricultural societies:

- Great changes in the energy input
- Fundamental characteristics of agricultural societies are very similar all over the globe
 - **convergent evolutionary processes!**
 - **no goal-oriented steering**
- Radically different situation than the **current required Great Transformation:**
 - **goal-oriented and steered process!**
 - **highly differentiated globally**

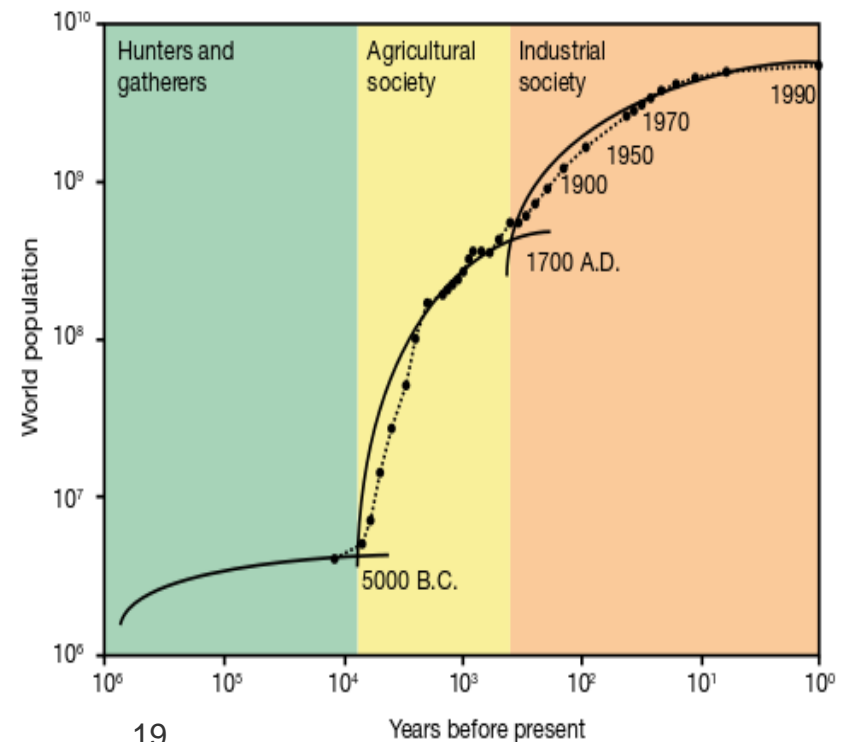
II. The Mobility Transformation as a **Great Transformation**

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II. Great Transformation processes

Review: The Industrial revolution

Complex process of social and economic “remodelling”

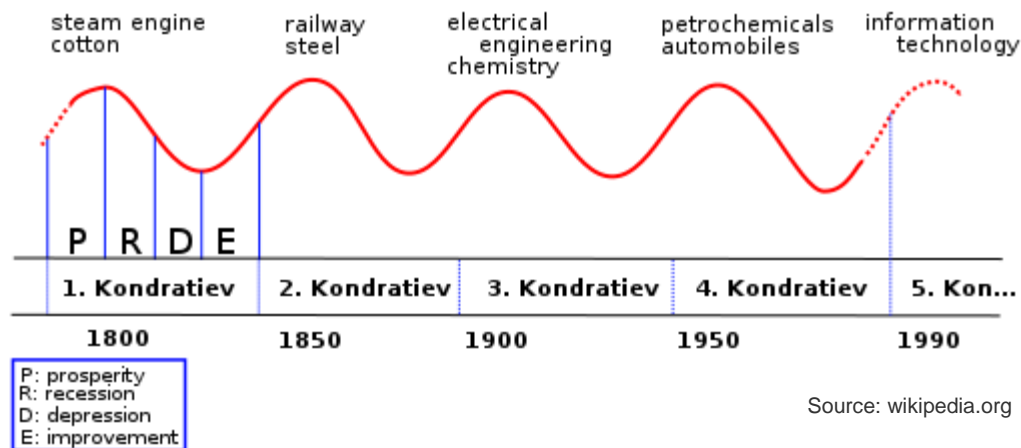
1. Based on major changes in the energy system and energy sources used
1. Replacement of **biomass**, manpower and animal power by **fossil fuels**: this process took ca. 70 years worldwide!
1. Conversion of economic and energy system was a long-term evolutionary process accompanied by modifications to existing institutions and labour structure

II. Great Transformation processes

Review: The Industrial revolution

Complex process of social and economic “remodelling”

4. **Key technological innovations**, e.g steam-engines, **automobiles**, electricity, steel production, mass production, etc., lead to profound economic change and transformative investment
- This economic cycles called „**Kondratieff-waves**“ occur every 40–60 years



Source: wikipedia.org

II. Great Transformation processes

Review: The Industrial revolution

Consequences of the industrial revolution

- change in the **energy basis** of society and economy: increased productivity
- the significance of **time** for the economy, and in society: acceleration and homogenization processes (standard world time in 1884 – International Meridian Conference)
- communication, knowledge and logistics **infrastructures**: globalized society but also **network structures!**
- power transformation and social change: e.g. defeat of the European colonial powers, more participation possible

II. Great Transformation processes

A look forward:

The upcoming Mobility (Great) Transformation would be:

- Goal-oriented: low-carbon mobility
- Differentiated globally: many possible concretizations!
- Demanding steered/coordinated and target-oriented action plans

...neither the Neolitical nor the Industrial revolution were directed and controlled processes!!

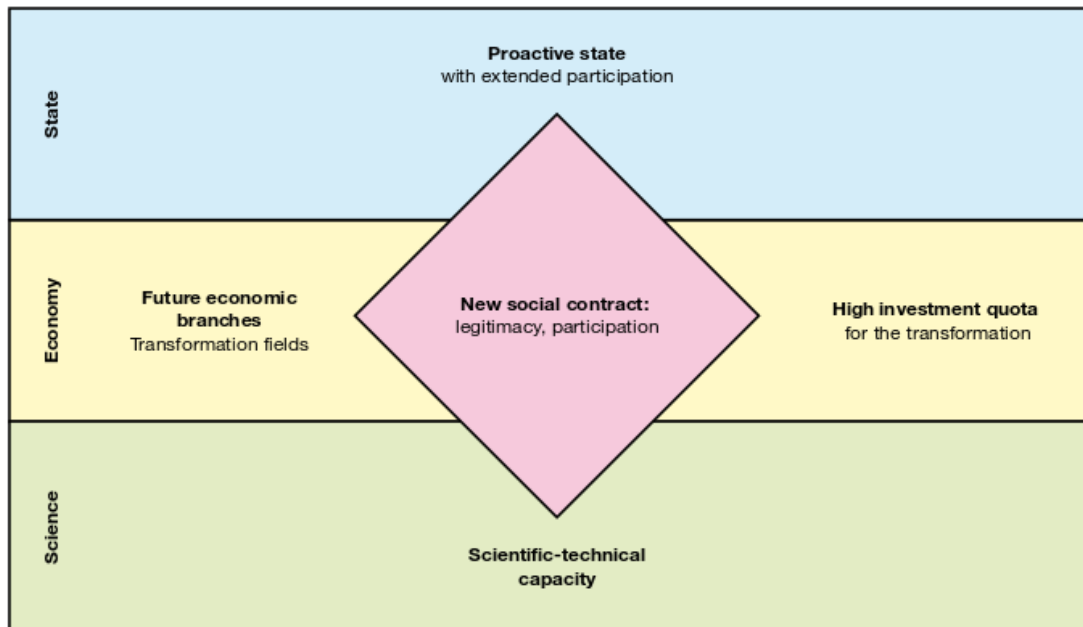
...So let us look at the general characteristics of such Transformations to try to adapt them to **the mobility one!**

II. Big Transformation processes

Such Great Transformation processes ...:

- „Rely on a great number of changes in **different socio-technical (sub)systems**, and take place at **local, national and global levels**”
- „are influenced by a **large number** of political, scientific, economic and civil social **actors** and consumers”
(WBGU, 2011, p.90)

Source: WBGU, 2011,

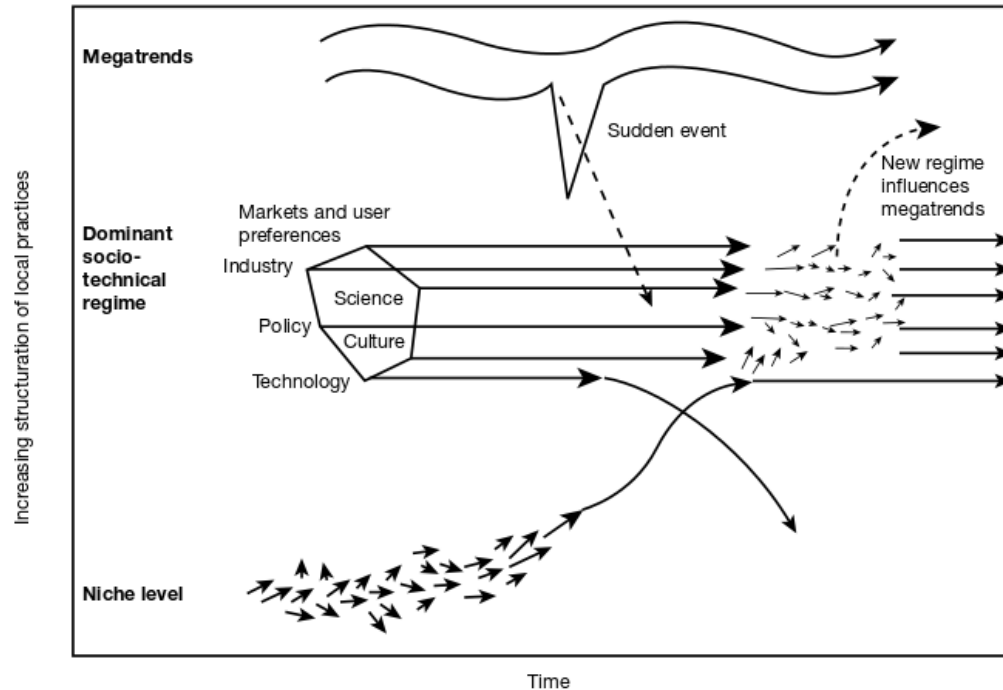


Different focus
groups

II. Big Transformation processes

Such Great Transformation processes ...:

- *Include the development of (niche) innovations as well as their selection on the part of the users, and their social embedding through markets, regulations, infrastructures and new social guiding principles (WBGU, 2011, p.90)*

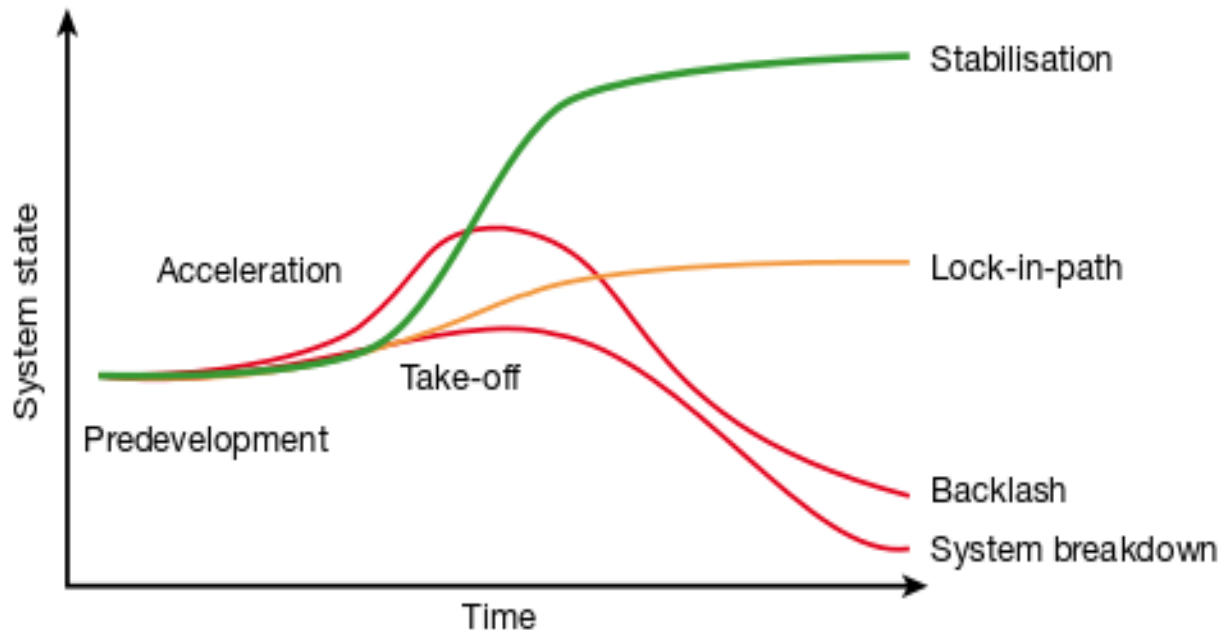


Source: WBGU, 2011;

II. Big Transformation processes

Such Great Transformation processes ...:

... are not linear!



II. Great Transformation processes

A look forward

Decarbonization of Mobility as an example!: “mobility reloaded”

Driving processes

1. Major changes in energy system: grid, charging stations,...
2. Shift from fossil fuels to RE
3. Socio-economic impacts!: productivity, commuting, access, wellbeing,...
4. Key technology innovations: batteries, self-driving cars, car-sharing apps,...



Driverless Car Mishap #13

Consequences

Infrastructure

Economy: costs, productivity

Environment: resources and sinks

Policy frames

Mobility demands

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Questions for group work

Each group addresses a different perspective on the mobility transition:

From **your (group's) perspective...**

1.-...are we able to keep up with current mobility trends in Germany with a 100% RE supply?

+ What are current growth rates relevant in your dimension? How are they evolving?
(*e.g. E-vehicles sold, Person-Km, Efficiency of vehicles,...*)

2.-...what are there processes/changes required for promoting a 100% RE supply?

+ Which current measures/processes are promoting a 100% RE supply in your dimension? (*e.g. policy framework, oil prices, battery features,...*)

+ Which additional processes/measures would speed up achieving a 100% RE supply in mobility in Germany? (*be creative here! - there is still plenty of time in the seminar to narrow down your choices! ;-D*)