Sustainability transitions and net-zero

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Outline

1. Grand sustainability challenges
2. Energy transition
3. Sustainability transitions
4. Net-zero: Phases & strategies

1 Grand sustainability challenges

We need to change ...

Climate change: IPCC 2021

"Recent changes in the climate are widespread, rapid, and intensifying, and unprecedented in thousands of years.

"Unless there are immediate, rapid, and large-scale reductions in greenhouse gas emissions, limiting warming to 1.5°C will be beyond reach.

Some particularities of climate change

- Slowly changing system
  takes years/ decades to see the changes but also to mitigate them
- Some changes will be irreversible
  e.g. rainforests, gulf stream
- Potential tipping points
  which even accelerate global warming
  thawing of permafrost, greenland ice shield
  https://www.weforum.org/agenda/2019/12/climate-change-tipping-points-earth/

Grand Sustainability Challenges

- Require fundamental changes
  in how we produce and consume things
  → changes in technologies, policies, business models, lifestyles etc.
- Changes involve multiple sectors such as
  energy, transport, agri-food, water etc.
  → system change
- For research, we need a
  systems-based theory of change
  → socio-technical transitions

Grand sustainability challenges as wicked problems

- Complex problems, not fully understood, multiple causes
- Competing solutions, high uncertainty, no easy tests
- Multi-dimensional: technical, social, ecological, economic issues
- Conflictive: viewed differently by different stakeholders
- Value laden
- Moving target(s)
- Global scope, public good character

"Wicked problems"
Head & Alford 2015, Admin Soc
Mowery, Nelson, Martin 2010, Res Pol
Levin, Cashore, Bernstein, Auld 2012, Pol Sci
Ferraro, Etzion, Gehman 2015, Org Studies

2 Energy transition

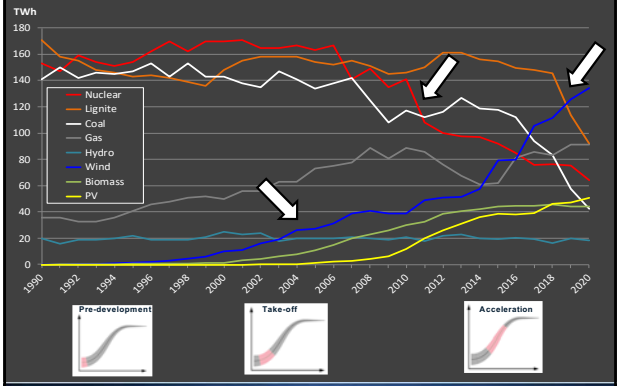
Energy transition

- Fundamental change of energy sector(s); takes 30 - 50 yrs

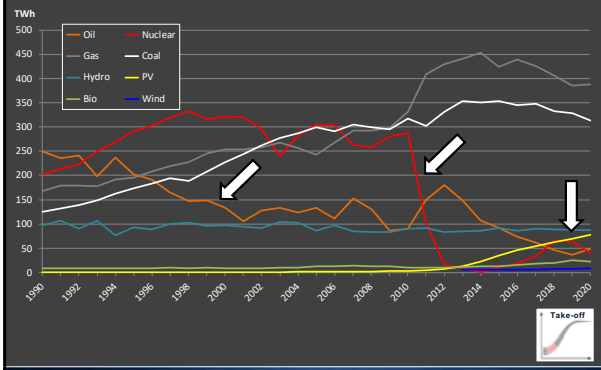
  Historic transitions:

- Ongoing transition:
  Renewable energies (wind, solar, biomass)
  replace fossil & nuclear energy

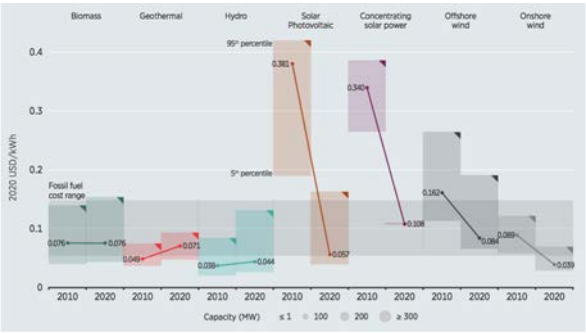
Germany: Electricity generation



Japan: Electricity generation



Rapidly decreasing costs of renewables



Source: IRENA 2021

3 Socio-technical transitions

Historical transition example: automobile

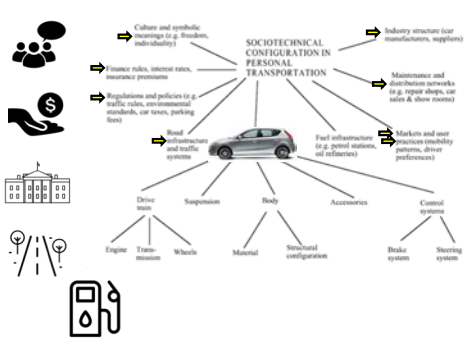


Development of (core) technology


Development of infrastructure

Geels 2005

Central concept: Socio-technical system



adapted from Geels, 2002

Socio-technical transitions

technological, organizational, institutional, political, socio-cultural

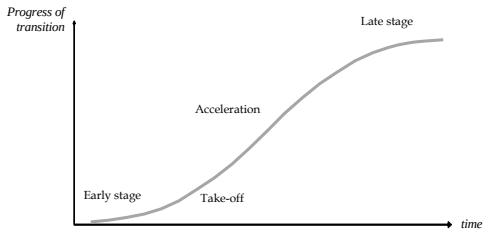
e.g. 30-50 years

Fundamental, multi-dimensional, long-term changes of socio-technical systems (Geels 2002; Smith et al. 2010)

disruptive, competence destroying innovation; different parts of the value chain

e.g. transport, energy, agro-food etc.

Transitions are non-linear



Rotmans et al. 2001

Sustainability Transitions

- are socio-technical transitions
  of sectors such as energy, transport, agro-food, or water
  that are associated with sustainability targets [and 'guided' by public policies]
  (Markard et al. 2012)

- Implicit normative assumption
  that *sectors* are unsustainable and *have to change*
  e.g. to achieve SDGs

"Sustainability Transitions"
Geels, Sovacool, Schwanen, Sorrell 2017, Science
Koehler, Geels, Kern et al. 2019, Env Innov Soc Trans
Markard, Raven, Truffer 2012, Res Pol

Multi-level perspective (Geels 2002, 2010, 2011)

Socio-technical regime

- Knowledge, engineering practices and technological artifacts seamlessly intertwined with user skills & expectations, institutional structures, organizational practices, infrastructure (Kemp et al. 1998)
- Highly resistant to change; imposes a direction of technological development (→ pathway)

Niche

- Protected spaces in which radical innovations can grow

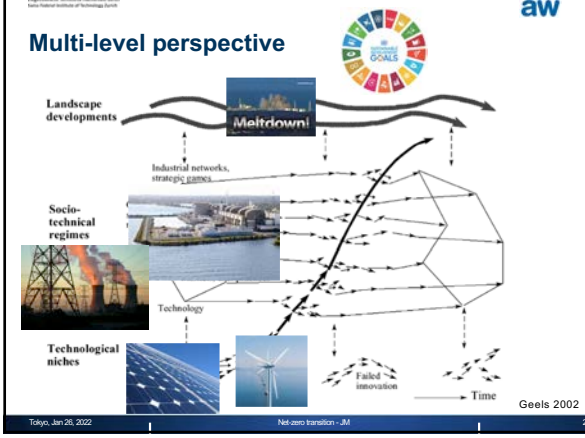
Landscape

- Exogenous factors that affect technology development

General dynamic

Landscape developments destabilize regime, niche innovations break through

Multi-level perspective



Geels 2002

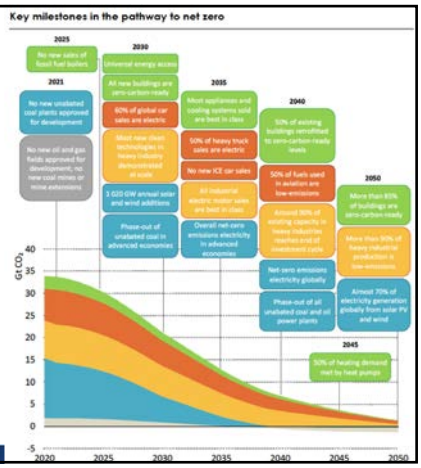
4 The transition to net-zero

together with Daniel Rosenbloom
in preparation for: Handbook of Energy Transitions

Net-zero emission targets

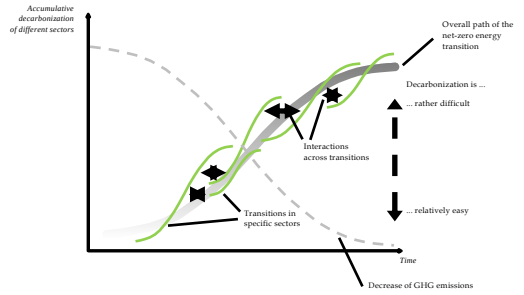
- Over 120 countries: net-zero commitments until ~ 2050
  - US, European Union, UK, China, Japan, Canada
  - Japan: hydrogen, offshore wind, ammonia
- Net-zero is a game changer
  - requires a swift, radical & economy wide transition
  - no sector can escape!
    → especially difficult-to-decarbonize industries (Davis et al. 2018)
    such as cement, steel or chemicals face new challenges

IEA: Net-zero milestones



How to conceptualize the net-zero energy transition?

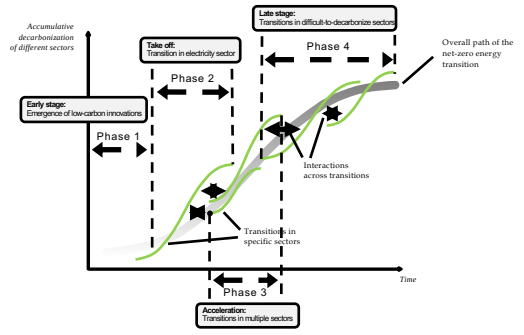
- Multiple transitions in different sectors (see also Schot & Kanger 2018)
- Cumulative nature: individual transitions need to complement each other
  → towards overarching goal
- Each transition entails multiple innovations
  (e.g., renewables, heat pumps, electric vehicles, hydrogen etc.)



Policy challenge ...

- Key role for policymaking to guide transitions
  - make sure that transitions complement each other
  - avoid dead-end pathways & trade-offs (Meadowcroft et al. 2019)
  - avoid counteracting developments (Markard et al. 2021)
- Increasing complexity: as the scope of the transition increases, policy challenges accumulate
- Qualitatively different phases of development
  - One or more sectors involved
  - One or more strategies

stylized model, builds on historic developments (in some places) & future necessities



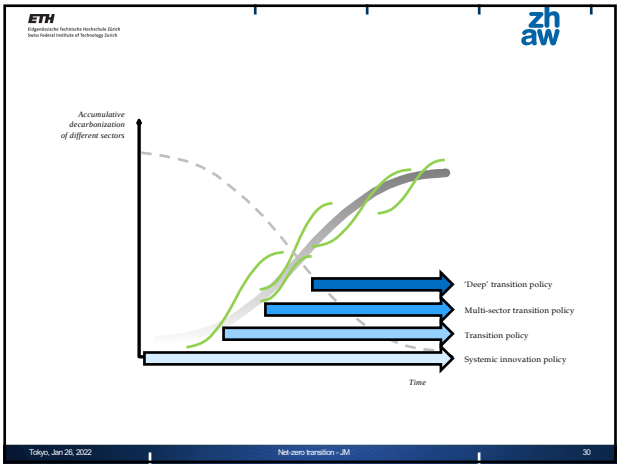
Four major transition phases (overlapping)

- Phase 1: Low carbon emergence
  → variety of low-carbon innovations in multiple sectors
- Phase 2: Decarbonization of electricity
  → maturation of wind & solar, first low-carbon transition, one sector, emergence of a dominant paradigm
- Phase 3: Cross-sector electrification
  → «electrify everything», one approach, multiple sectors
- Phase 4: Deep decarbonization
  → multiple sectors, multiple strategies, difficult-to-decarbonize sectors



Policy challenges

- Since phase 1 (and until late stage):
  Systemic innovation policy → Stimulate radical innovations, strategic niche management, mission oriented innovation (Smith & Raven 2012, Hekkert et al. 2020)
- Since phase 2 (until late):
  Transition policy → Support innovation diffusion (e.g. through market formation) and decline (e.g., through phase-outs) (Rosenbloom et al. 2020)
- Since phase 3 (until late):
  Multi-sector transition policy → Coordinate policies across sectors, avoid trade-offs or dead ends (van den Bergh et al., 2015; Meadowcroft et al. 2019)
- Since phase 4:
  Deep transition policy → Also address radical economic transformation & changes in lifestyles



How to tackle decarbonization?

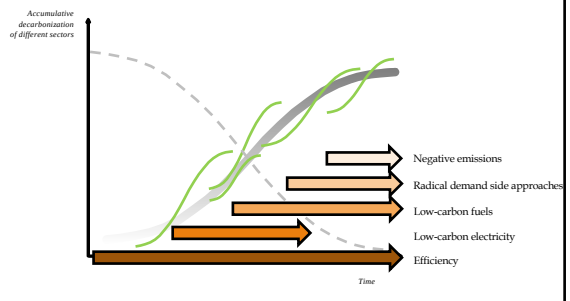
- Different sectors (e.g., transport, electricity, industry) and different applications (e.g., automobiles, trucks, shipping, aviation)
- Decarbonization *strategies*
  → Specific ways to realize decarbonization that center around a 'guiding principle' (e.g., improvement of efficiency) and involve a broad variety of approaches / technologies (e.g., LED light bulbs) for different applications (e.g., lighting)
- Multiple innovations may be needed to realize a strategy, e.g. electric mobility: battery technology, vehicle, charging stations, low-carbon electricity ...
- Strategies vary:
  - fit with specific applications / sectors (e.g. fuels → aviation, shipping)
  - dominance
  - reduction potential (e.g. efficiency leaves residual consumption)
  - maturity

Major decarbonization strategies

- Energy efficiency
  Saving: reduce room temp., switch off unused loads
  Efficient technologies: LED lighting, fuel efficient cars
- Low-carbon electrification
  Technological innovation: Renewables, EVs, batteries
- Low-carbon fuels
  Biofuels: Ethanol, Biogas
  Hydrogen: New synfuels, CCS
- «Untapped demand-side approaches»
  Lifestyle changes: car-free housing, no commute
  Radical substitution: Wood instead of cement & steel
  Restrict new high-carbon energy use, e.g. space tourism

Limitations

- No reduction to net-zero
- Dependent on user involvement
- Limited reach: not for DDIs
- New impacts (e.g. minerals)
- Land use conflicts
- Costs
- Inefficiency
- Import dependency
- Major resistance by users, policy and industry
- Regulatory changes needed



Developing new strategies

- Different strategies needed for net-zero, ideally use the most effective first (quick, high reduction potential)
- New strategies & technologies needed
- Traditionally: strong focus on supply side, demand side neglected!
  but: hydrogen points to limitations of this approach
  → prepare complementary demand-side strategies

6 Summary

Summary

- Grand sustainability challenges:
  highly complex, special approaches needed
  "transition studies" one such perspective
- Sustainability transition studies:
  Net-zero energy transition as a cumulative process
  of interdependent transitions in multiple sectors
- Phases:
  Qualitatively different phases of development,
  increasing complexity for policy making,
  new strategies needed for net-zero

Thank You!

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