Aalto University
School of Business

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Finnish Environment Institute

SMART ENERGY TRANSITION

Sustainability transition approaches and energy transitions

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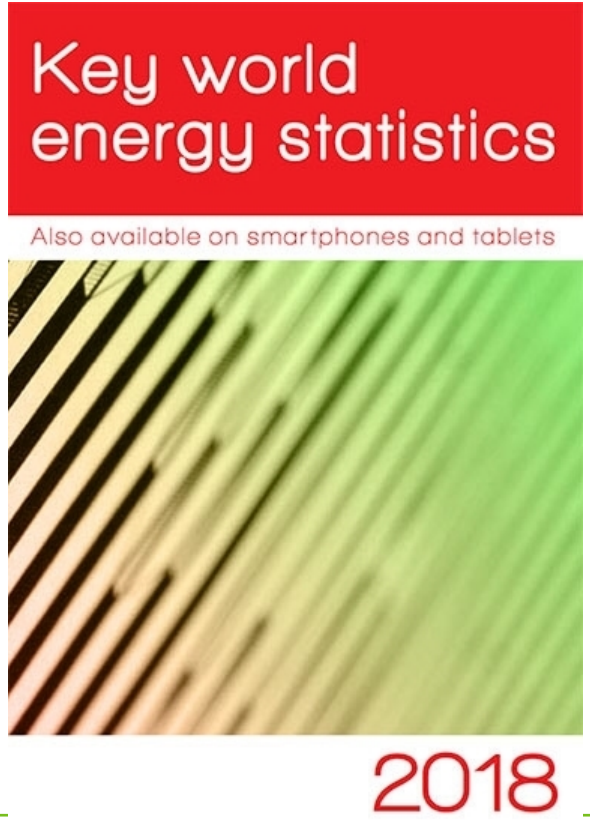
What are sustainable energy transitions?

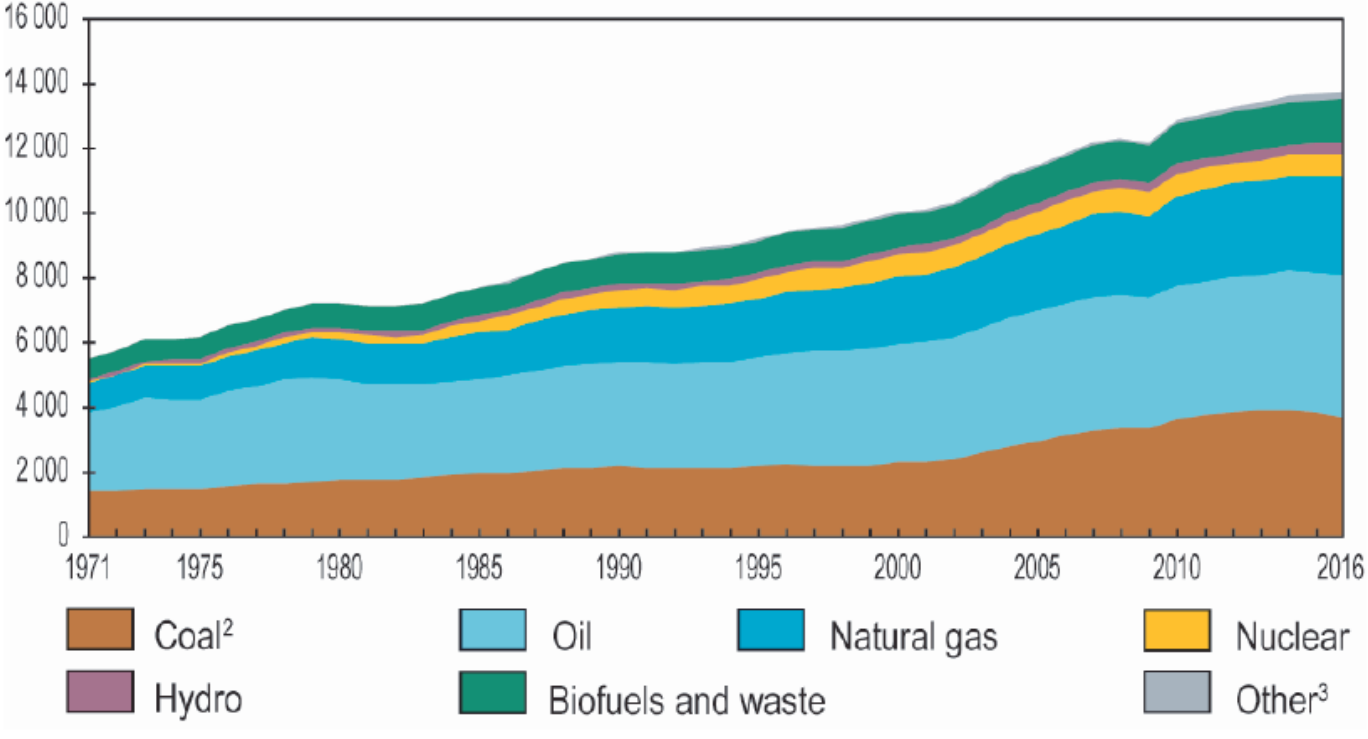
Global energy transition?



- **On the large scale energy production, rather little change is visible**
- **Yet, upward trends in renewable energy sources and a downward trend in coal (particularly in OECD countries)**

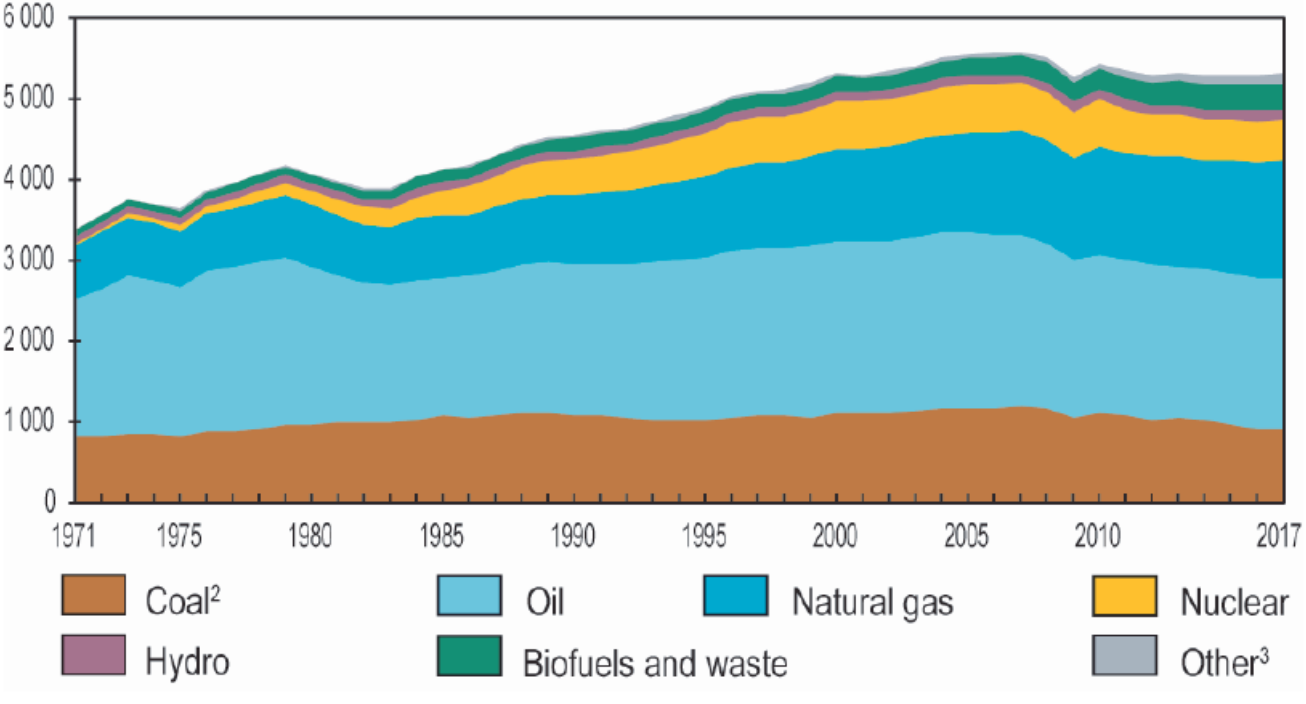
World total primary energy supply (TPES) by fuel

World[1] TPES from 1971 to 2016 by fuel (Mtoe)



OECD total primary energy supply by fuel

OECD TPES[1] from 1971 to 2017 by fuel (Mtoe)



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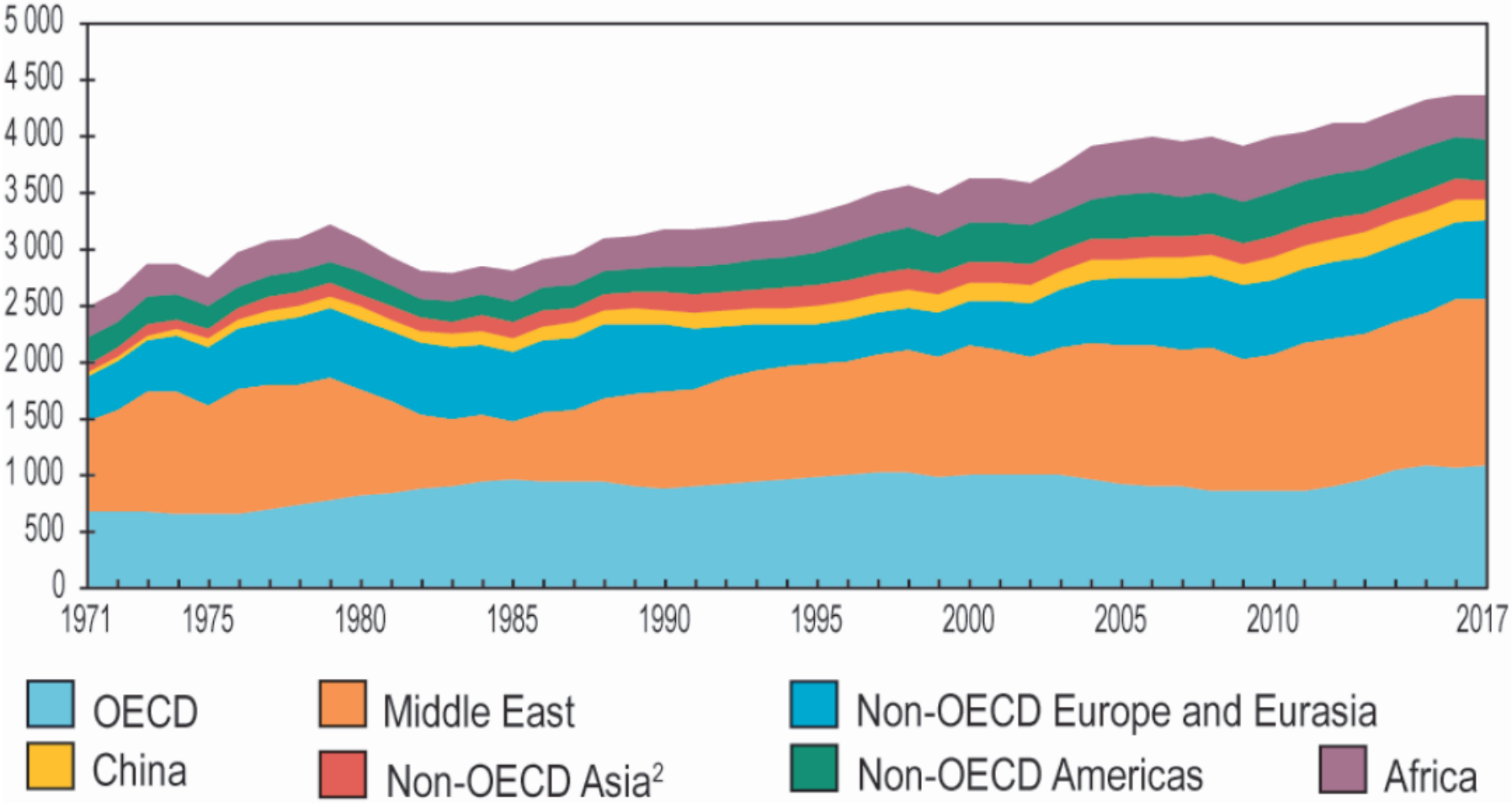
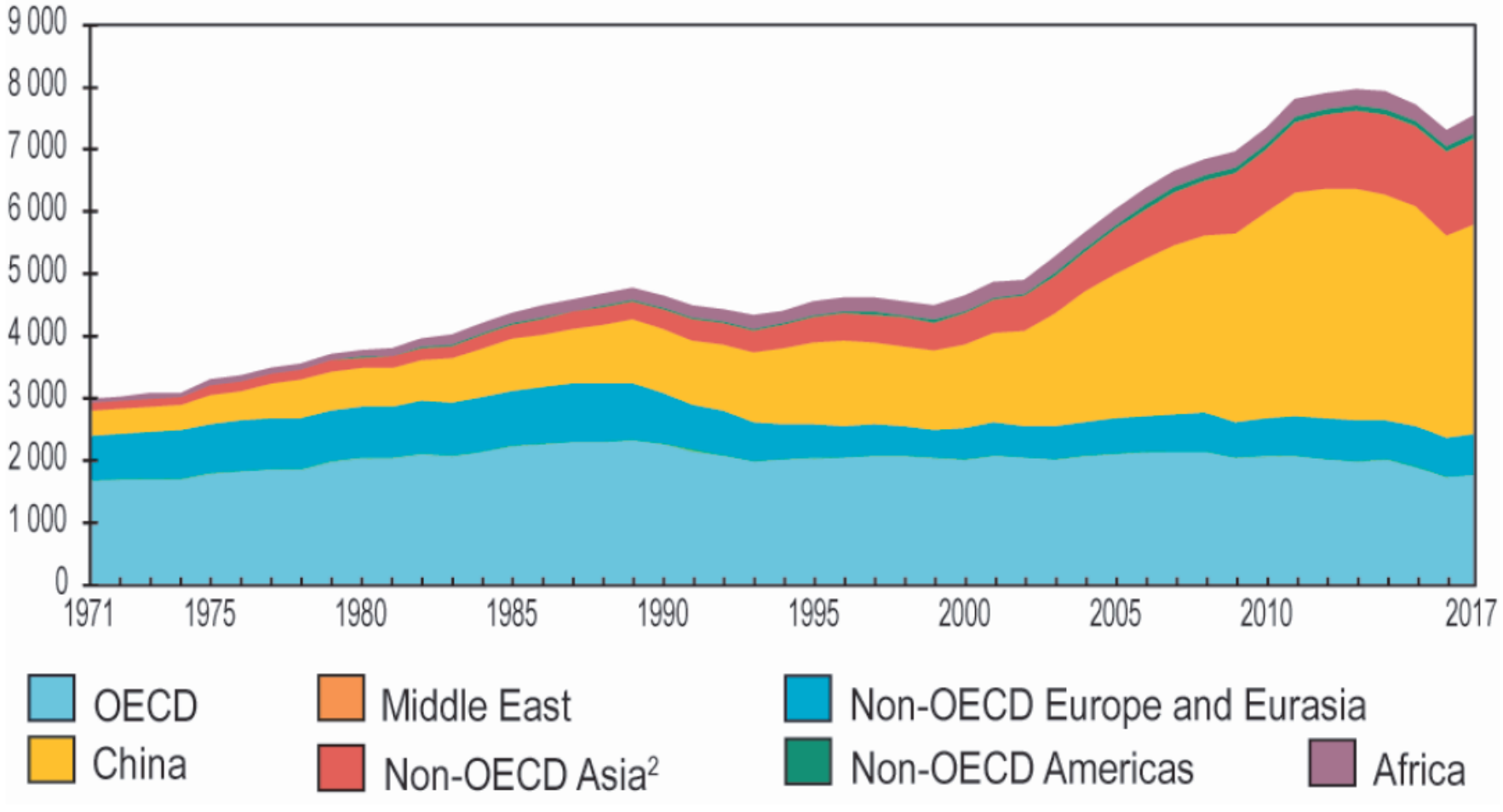
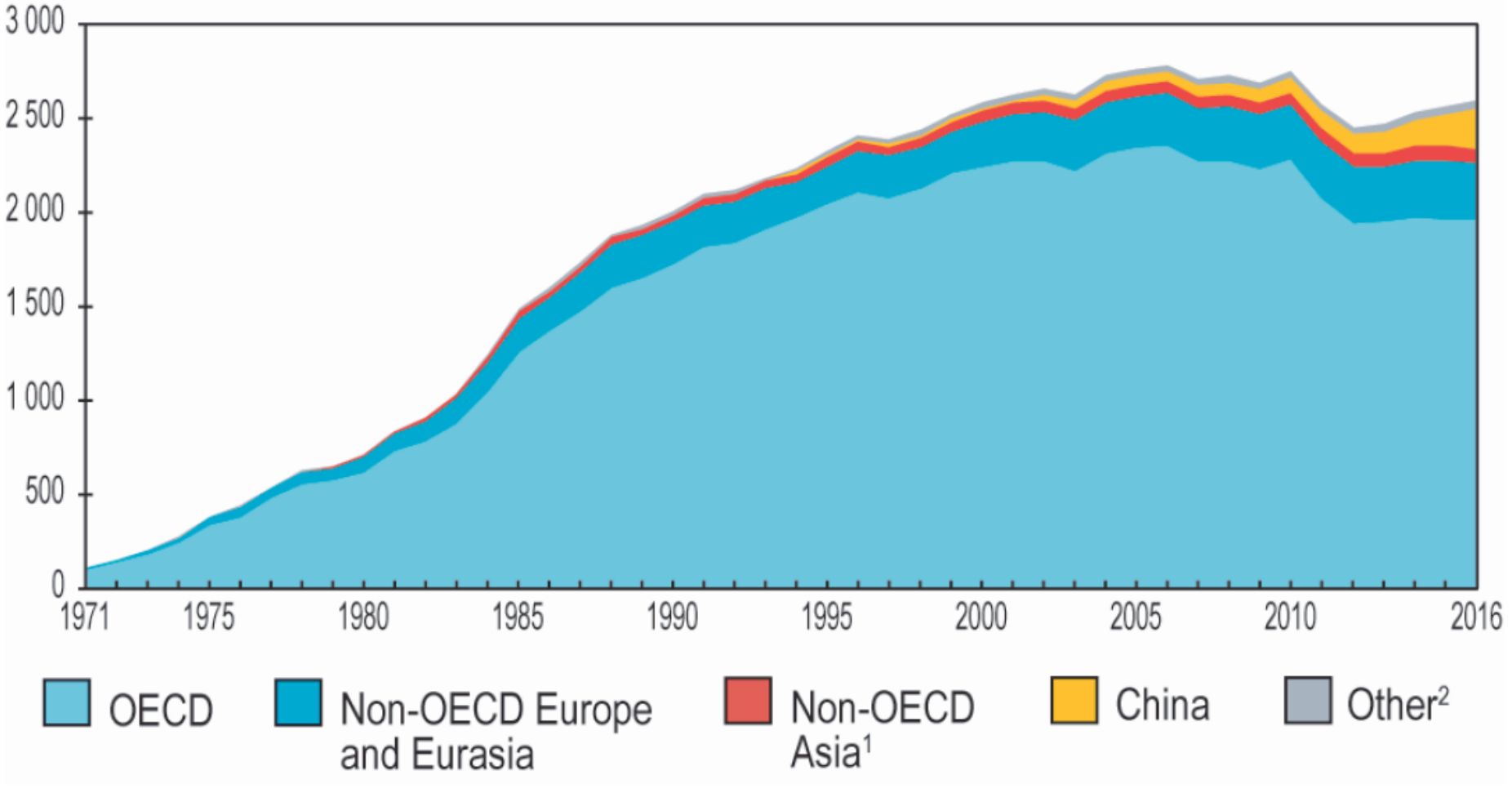
World crude oil[1] production from 1971 to 2017 by region (Mt)



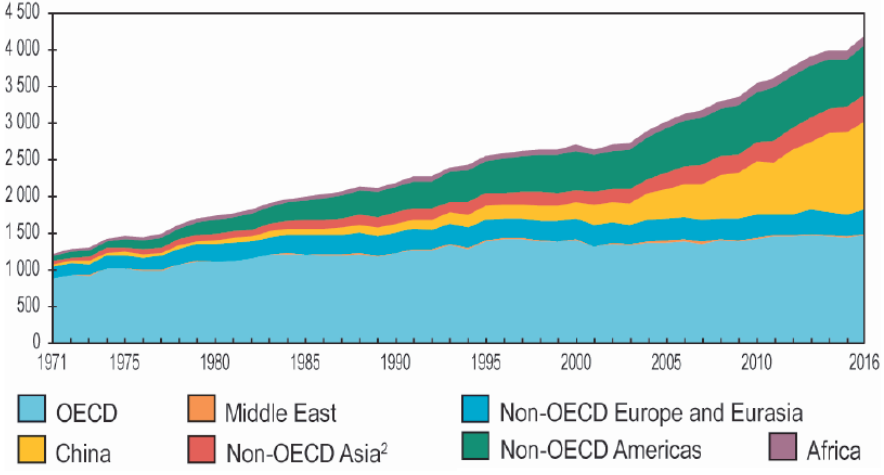
World coal[1] production from 1971 to 2017 by region (Mt)



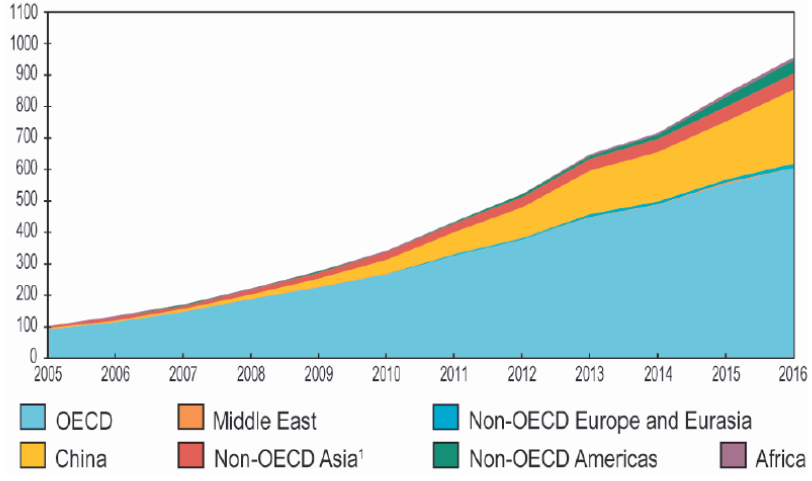
World nuclear electricity production from 1971 to 2016 by region (TWh)



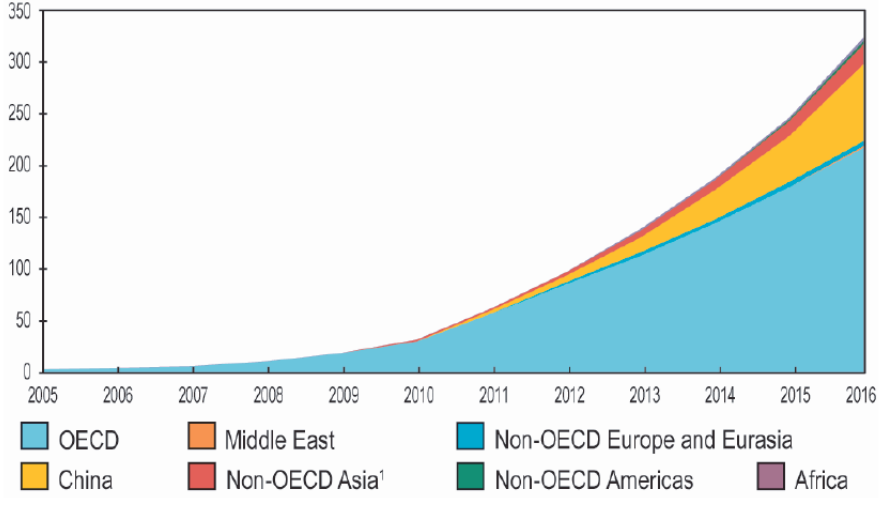
World hydro electricity production[1] from 1971 to 2016 by region (TWh)



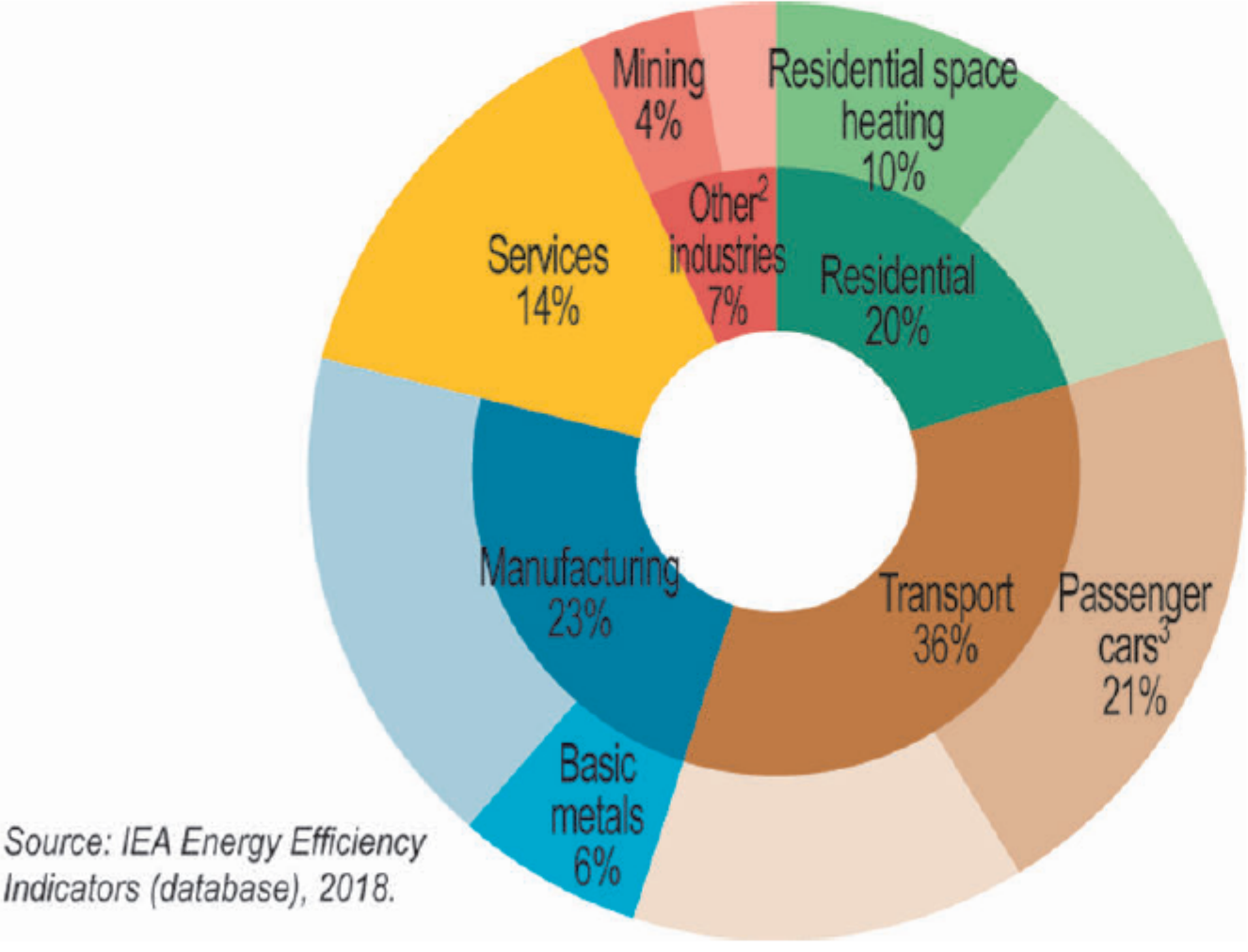
World wind electricity production from 2005 to 2016 by region (TWh)



World solar PV electricity production from 2005 to 2016 by region (TWh)



Largest end uses of energy by sector in IEA[1], 2015



Source: IEA Energy Efficiency Indicators (database), 2018.

Sustainable energy transitions

- **Renewable energy technology as a driving force BUT**

- **Also about**
  - New business models
  - New regulatory frameworks
  - Ownership structures of energy production
  - New routines and practices

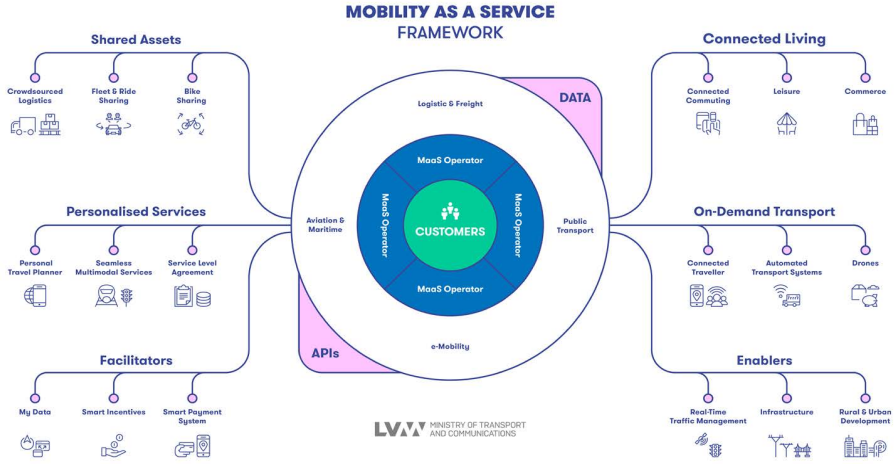
New business models

Energy services for buildings

Energy services for mobility

Renewable energy based services by incumbent utilities

(More about this 21.5.)



New regulatory frameworks

Allowing micro-scale renewable energy to be sold to the grid

Making mobility operators data and ticket interfaces open for the development of new mobility services

Designing regulation for phasing out coal and/or nuclear power

Changing ownership structures

- **In some countries, e.g. Germany, energy transitions also connect to changes away from large corporate ownership of energy production**

- **New concepts**
  - Prosumerism
  - Community energy

(More about this 14.5.)

New routines and practices

- **The role of the consumers is significant in more sustainable energy systems**
  - Active users of new services: holistic energy planning and management for households, new mobility services, demand response (reduction of unnecessary use or timing use more wisely)
  - Installing and owning renewable energy production
  - Thinking about your mobility needs, mode of transport and when to travel

Sectoral boundaries became blurred in energy transitions

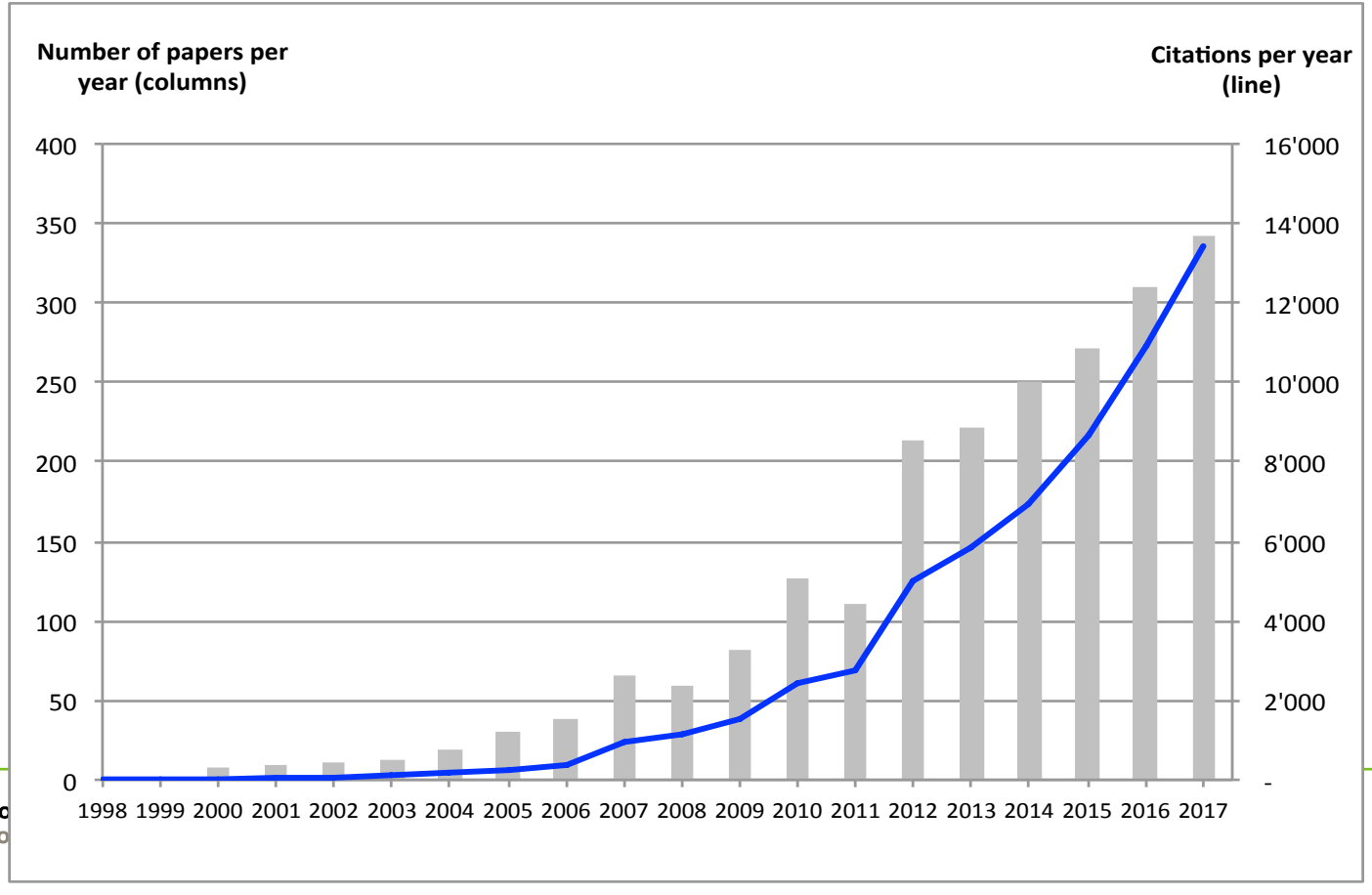
- **Examples:**
  - Electrification of the energy sector and transport
  - Improved integration of ICT to improve energy planning and mobility services
  - Use of agricultural crops or waste for energy production

Sustainability transitions literature

- **Originated in the late 1990s as an interdisciplinary social science research field, with an aim to tackle fundamental *environmental* sustainability challenges**

- **Tries to understand socio-technical system change through**
  - (a) creation and diffusion of innovations (niches, technological innovation systems)
  - (b) path dependencies, lock-ins and the processes of destabilising socio-technical regimes/systems
  - (c) influence of broader landscape changes

No. of papers on sustainability transitions in peer-reviewed journals and citations



Source: STRN strategy, 2018

Institutionalisation of the field

- **Academic journal: Environmental Innovation and Societal Transitions (Elsevier)**
  - https://www.journals.elsevier.com/environmental-innovation-and-societal-transitions/

- **Sustainability Transitions Research Network (STRN)**
  - www.transitionsnetwork.org
  - New research agenda!

- **PhDs and Early career researchers in transitions (NEST)**
  - https://transitionsnest.wordpress.com/

Interest in sustainability transitions in practice

Socio-technical system

- **E.g. energy supply, water supply, transportation, food supply**
- **"*consists of (networks of) actors (individuals, firms, and other organizations, collective actors) and institutions (societal and technical norms, regulations, standards of good practice), as well as material artefacts and knowledge"***
- **Different elements of the system interact providing services for the society**

Markard et al. 2012

Socio-technical transition

- "***set of processes that lead to a fundamental shift in socio-technical systems***"
  - Contains extensive changes along different dimensions: not just technological, but also organisational, institutional, political, economic, and socio-cultural
  - Include a large variety of actors
  - typically take a very long time (> 50 years).
  - During a transition, new products, services, business models, and organisations emerge
  - Technological and institutional structures undergo fundamental changes

Markard et al. 2012

Historical examples

- From sail boats to steam ships
- From horse drawn carriages to motor vehicles
- From cess pools to sewer systems

- BUT the present challenge is how to promote large-scale transitions supporting environmental sustainability (rapidly)

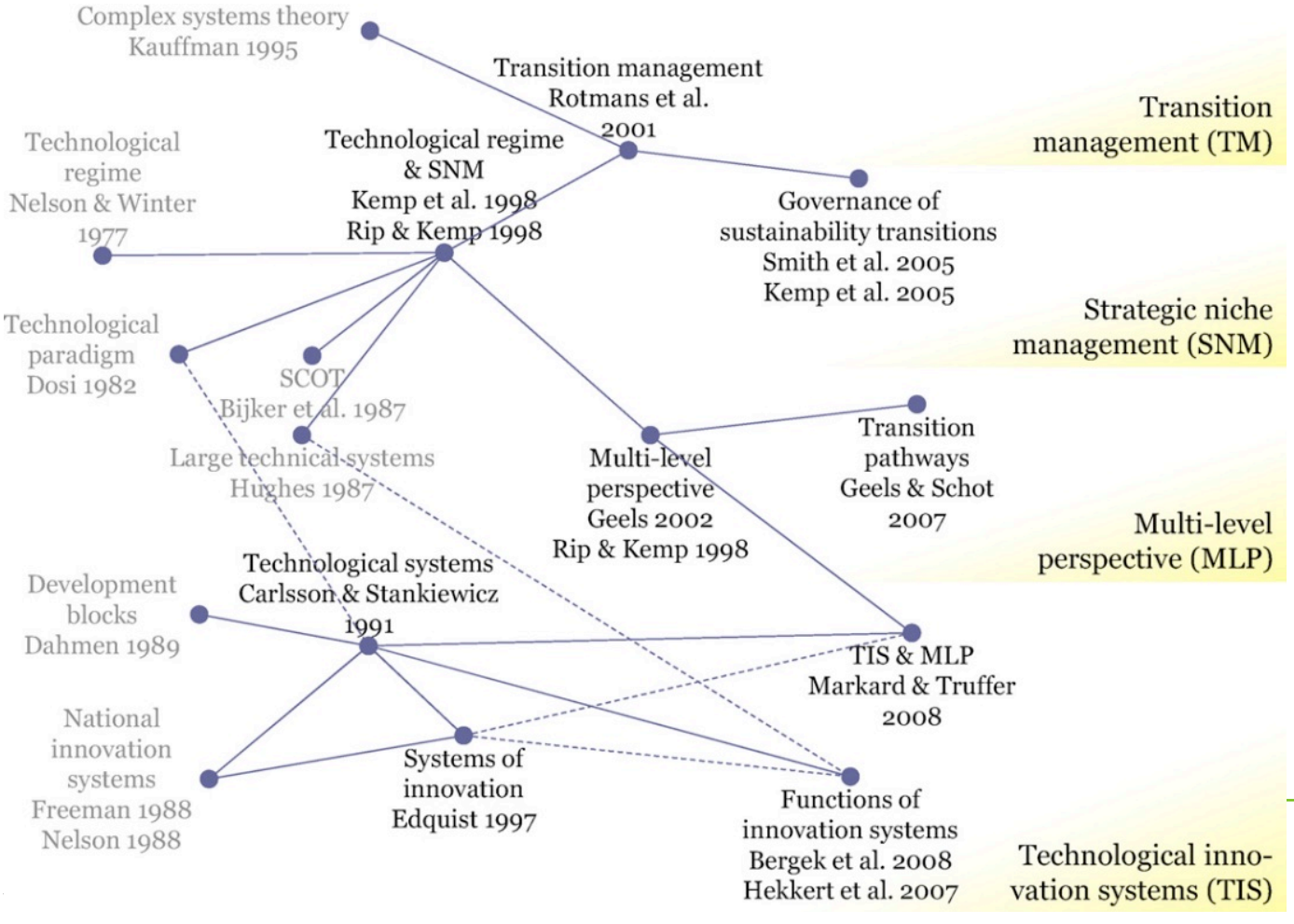
Path dependency and lock-in

- **"History matters"**
  - While a given path, such as fossil-fuel-based private transport, is in the initial circumstances the "best" choice, various system components (build-up of surrounding infrastructure, urban form, institutions, practices, etc.) often cause such paths to lock-in. (Makinen et al. 2015)
  - This means they persist against change even when they become inefficient or inferior to alternative paths.

Makinen et al. 2015

- **Energy system lock-in**
  - Large fixed costs and lower running costs of coal/nuclear power plants
  - Knowledge and skills, business models and markets built around existing (environmentally inferior) technologies
  - Large set up or fixed costs acting as barriers to entry (e.g. grid connection)

Four core conceptual approaches



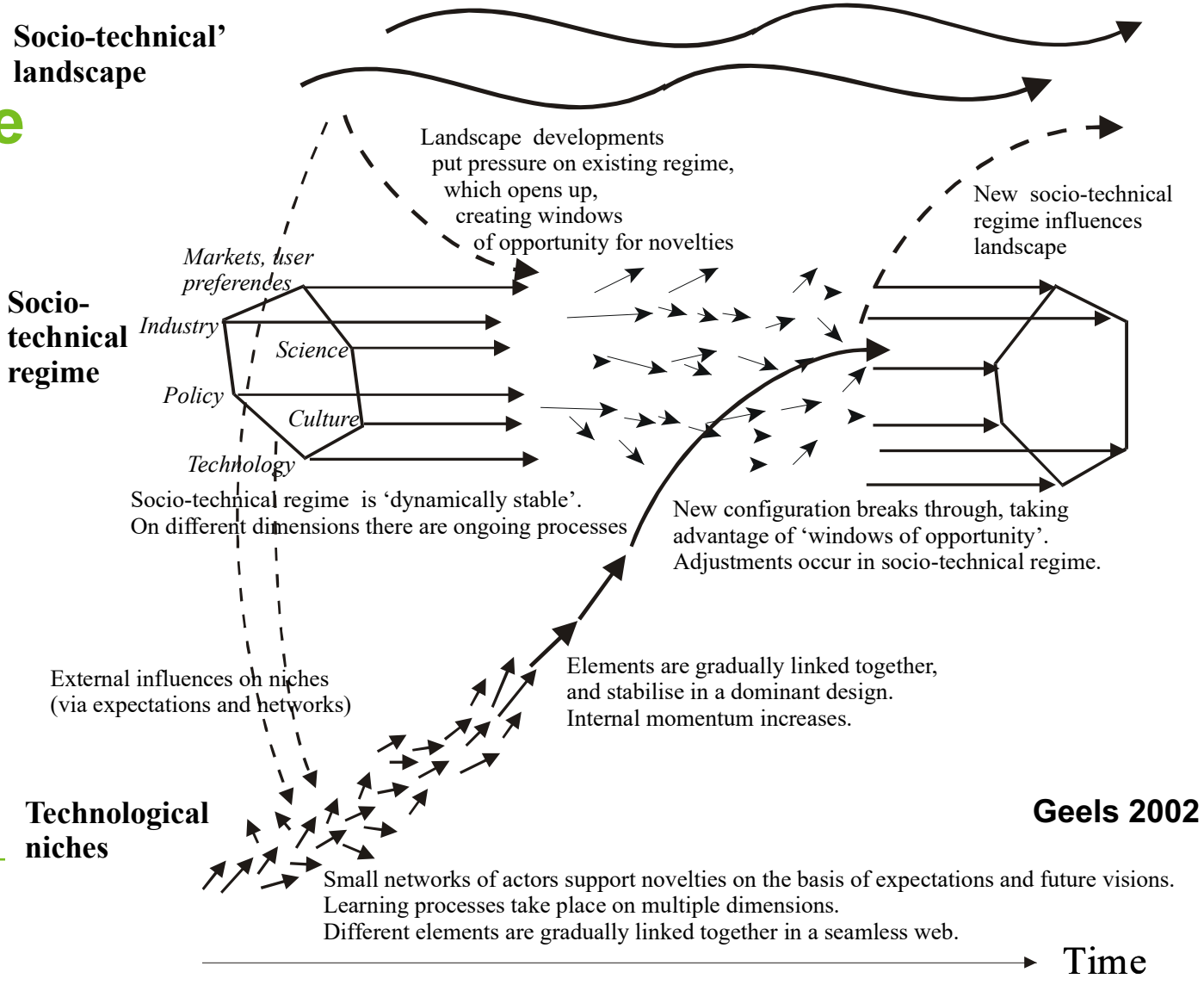
Markard et al. 2012

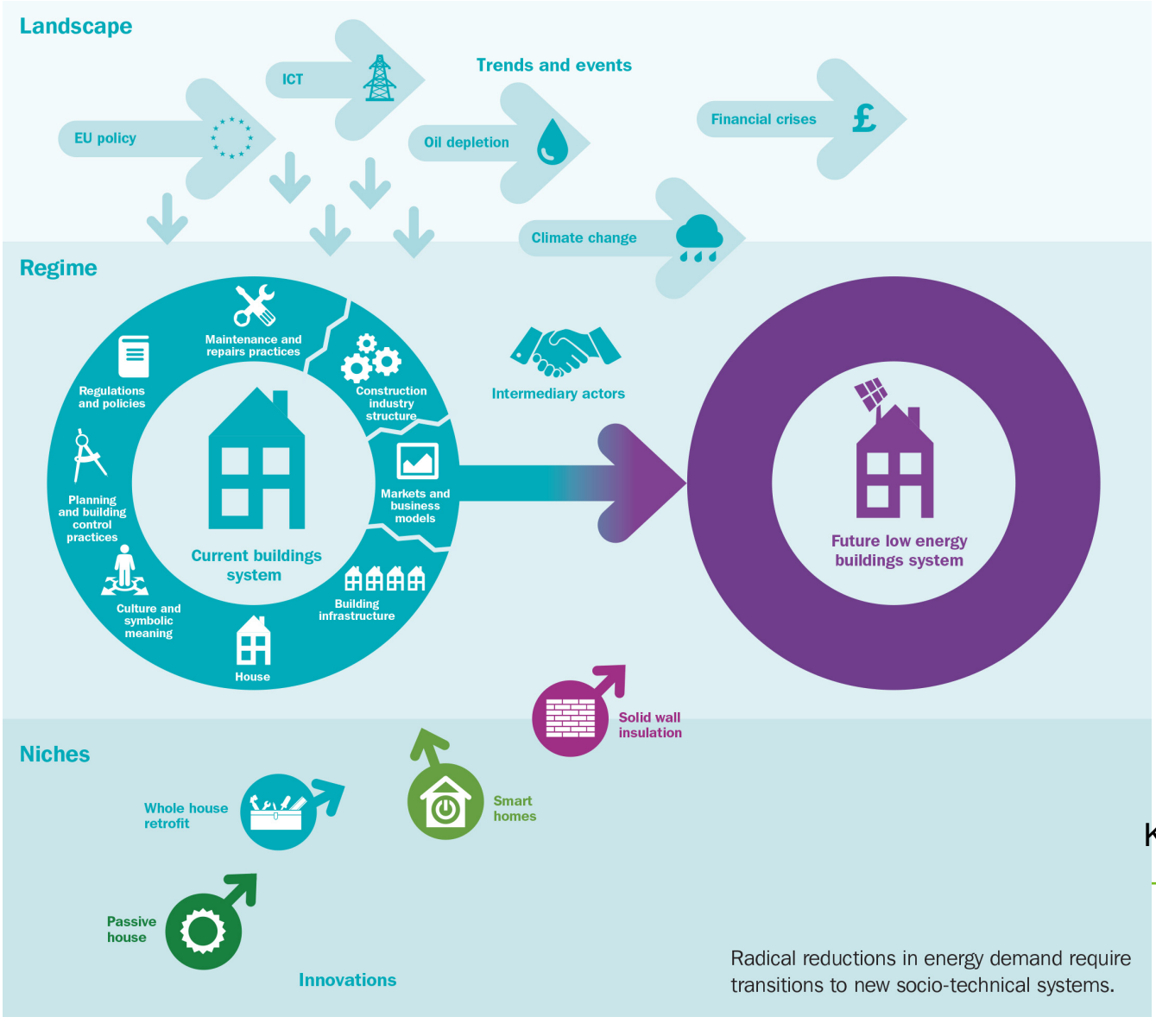
Cross-cutting concepts

- **Socio-technical regime** = the deep structure of the socio-technical system involving alignment between technologies, infrastructure, institutions, practices, behavioural patterns, markets, industry structures, etc. (Geels 2002, 2004)

- **Niche** = protected space, i.e., a specific market or application domain, where radical/disruptive innovations can develop uninfluenced by the selection pressures of the dominating regime (Kemp et al., 1998).

Multi-level perspective (MLP)





Radical reductions in energy demand require transitions to new socio-technical systems.

Kivimaa & Martiskainen, 2016

Destabilisation

- **Increasingly more explicit attention is paid to how existing (energy) systems destabilise**
  - *E.g. decline of the UK coal industry (Turnheim and Geels, 2012, 2013)*
  - *Policies for destabilising unsustainable industries (Kivimaa and Kern, 2016)*

- **This involves**
  - *"weakening reproduction of core regime elements" (Turnheim and Geels, 2012)*
  - *Opening up of windows of opportunity for niche innovations to diffuse*

Strategic niche management (SNM)

- SNM was developed to better understand technological change in connection with economic and social changes, aiming to facilitate the adoption of new technology to social contexts (Hoogma et al., 2002).

- Three core processes (Hoogma et al., 2002; Geels and Raven, 2006):
  - (1) Articulation of expectations and visions shared by many actors and demonstrated by multiple projects: strong visions can attract external support for the niche.
  - (2) Creation of networks enabling niche actors to interact, form partnerships and pool collective resources; and
  - (3) Learning in multiple dimensions, including aggregating best practice and lessons from projects and initiatives, and sharing knowledge towards local experiments.

Example: SNM roles undertaken by Sitra for sustainable energy transition in Finland

SNM process	Activity
Articulation of expectations and visions	- Articulating important issues, e.g. energy saving in communities and building regulations - Strategy development through participation in the revision of building regulations and ERA17 programme - Accelerating the application of new technologies, e.g. piloting and funding new solar technologies
Creating social networks	- Brokering between public and private sectors - Configuring and aligning interests between Sitra funded startups, city administrations and others
Learning in multiple dimensions	- Knowledge generation (background studies, pilots, competitions, visits, etc.) - Piloting and experimenting (e.g. new city area) - Investments in new innovative businesses - Communication and dissemination of knowledge (guidebooks, manuals) - Provision of advice and support (Peloton Campaign) - Learning by doing and using (competitions, demonstrations)

Technological innovation systems (TIS)

- **TIS adopts a systemic perspective to analyse the links between different actors, networks and the institutional contexts around a specific emerging technology (Bergek et al. 2008).**

- **A well-functioning TIS is regarded as a requirement for the development and diffusion of a technology**

- **Seven functions and ‘motors of innovation’**

Function	Explanation
Knowledge development and diffusion	Knowledge base and networks; how the knowledge is developed, combined and diffused.
Influence on the direction of search	Incentives and pressures for organisations to enter a field, inc. visions, expectations and demand.
Entrepreneurial experimentation	Testing of new technologies, applications and markets in such a way that new entrepreneurship and diversification forms.
Market formation	Factors driving new market formation, e.g. changes in customer or institutional demands and prices.
Legitimisation	Social acceptance and compliance with institutions and society.
Resource mobilisation	Financial and human factors and complementary assets as inputs for development.
Development of positive externalities	Benefits to others ‘free of charge’.

Jacobsson & Bergek, 2011; Suurs et al., 2010

Motors of innovation

- **The motors are argued to enable the build-up of TIS; they emerge over a long period of time and comprise abroad variety of activities (Suurs and Hekkert, 2009)**

  - Science and technology push motor
  - Entrepreneurial motor
  - Market motor

Example: Biofuels TIS in the Netherlands (1)

- **Emerging biofuel technologies 1990-1994**
  - system functions are beginning to take shape; they are mainly driven by external factors, some influence on the direction of search

- **Shaping of the biofuels TIS 1995-1997**
  - Influenced by entrepreneurial experimentation, knowledge development, direction of search, legitimisation → 'entrepreneurial motor' emerges as a results of the activities

Suurs & Hekkert 2009

Example: Biofuels TIS in the Netherlands (2)

- **Separation of 1G and 2G biofuels 1998-2000**
  - Dominant system functions include knowledge development, influence on the direction of search and resource mobilisation → 'science and technology push motor'

- **A tentative offer 2001-2002**
  - 'Science and technology push motor' has been effective, but markets are still missing

Suurs & Hekkert 2009

Example: Biofuels TIS in the Netherlands (3)

- **European intervention 2003-2005**
  - Increasing activity for all system functions; renewed direction of search due to the influence of the EU biofuels directive coupled with entrepreneurial experimentation, resource mobilisation and legitimisation → 'entrepreneurial motor'

- **A market in distress 2006-2007**
  - For 1G biofuels a 'market motor' enables diffusion
  - 2G biofuels are still driven by the 'entrepreneurial motor'

Suurs & Hekkert 2009

Summary of Technological Innovation Systems

- **Useful analytical tool highlighting the variety of factors needed to support innovation**
  - TIS functions can also be used for energy/innovation policy analysis to identify strengths and weaknesses

- **Does not address the destabilisation of existing systems**
  - Not sure whether the order of motors is the same or varies in different cases

Transition management (TM)

- A normatively oriented strand of the transitions literature
- Proposes a ‘tool kit’ for governing transition to achieve radical change towards more sustainable systems of production and consumption
- Differs from SNM by highlighting the importance of visioning *before* engaging in experimenting, thus, making experimenting more coordinated than SNM

Transition management (TM)

- combines the work on technological transitions with insights from complex systems theory (e.g., Kauffman, 1995) and governance approaches (Rotmans et al., 2001; Smith et al., 2005).

- TM scholars have proposed and applied an instrumental, practice-oriented model for influencing ongoing transitions into more sustainable directions (Kemp and Loorbach, 2006; Loorbach, 2010).

- Guiding principles for transition management are derived from conceptualizing existing sectors as complex, adaptive societal systems and understanding management as a reflexive and evolutionary governance process (Nill and Kemp, 2009; Voß et al., 2009)

- Based on action research and participation in regional and national policy projects
  - Starting in the Netherlands, but later applied in particular in urban contexts (e.g. Melbourne, Australia) and in Finland (e.g. energy transition arena, Blue Adapt)

TM as a process

1. Establishing a transition arena(s)
2. Developing a common vision
3. Pathway development through back-casting techniques
4. Experimenting with pathway options and
5. Monitoring, evaluation and revisions to pathways and experiments

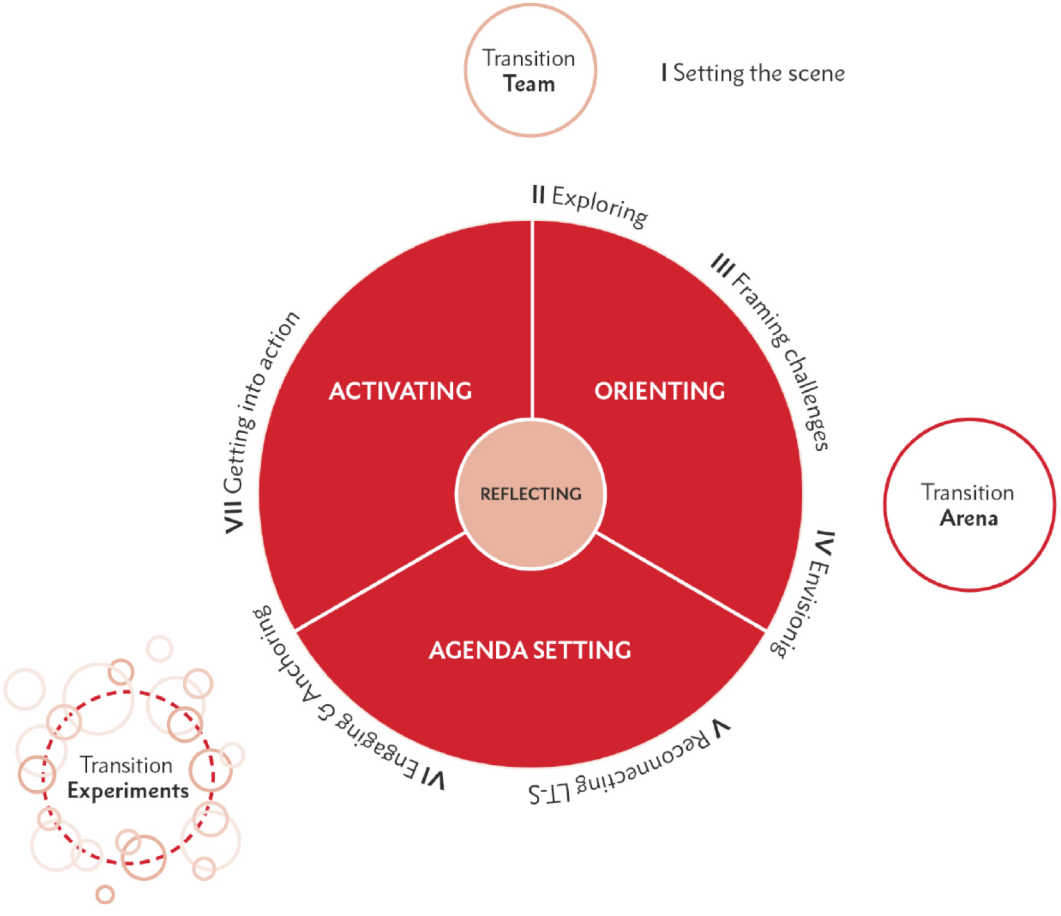


Fig. 7. Phases and settings of transition management.

Experiments in TM

- Transition arenas do not (necessarily) have the formal powers of (mainstream) policy developers (e.g. Frantzeskaki et al., 2012).

- Transition experiments (governance, technological, social) are expected to create outcomes through three different mechanisms:
  - deepening (learning as much as possible from the transition experiment),
  - broadening (repeating an experiment in an adjusted form in a different context)
  - scaling-up (embedding an experiment in the existing structures of the incumbent regime)" (Grin et al., 2010, p.146).

Design Issue	Transition management concept	Often in practice
Goals	Overcoming 'persistent problems' of environmental policy, achieving transition in socio-technical systems towards sustainable patterns of production and consumption.	Urban scale experimentation (sometimes successfully but in a small scale) or promotion of technological niches with commercial potential for the world market.
Organisation of transition arena	Visionary regime actors and innovative newcomers	Dominance by regime incumbents with vested interests
Role of visions	Construction of visions by frontrunners informs and precedes strategy development and design of experiments	Visions are constructed by incumbents and lack concreteness to inform strategies or select experiments
Experimentation	Real world experiments with portfolio of options for alternative socio-technical systems	Evasion of more permanent political choices with respect to technological options
Evaluation and Learning	Evolutionary selection process, options prove their feasibility in real world context, evaluation against potential to contribute to the vision	Evaluation by insiders according to narrow techno-economic criteria
Sources of legitimacy	The goal of sustainable development	Economic and technological position and expertise of participants

Adapted from Hyysalo, 2018

Adapting transition arenas to the Finnish context

- Transition management was applied in Finland in early 2000s
  - "Too Dutch": "too loose in comparison to regulation and too determining regarding markets"
- Finland has parliamentary Energy and climate roadmap to 2050, Mid-range climate plan to 2030 and Governmental energy and climate strategy to 2030 for setting mid-range goals
  - 140 energy related pilots www.energiakokeilut.fi and high emphasis on experimentation by current government
- Transition arena could connect the two

Adapted from Hyysalo, 2018

Energy transition arena in Finland in 2017

Objectives of the transition arena

- Supporting the implementation of Finland's 2030 Energy and Climate Strategy, and deliberating options not presented in the strategy
- Concretising transition paths (i.e. Creating an implementation strategy)
- Creating a Roadmap for change experiments, so that existing initiatives connect to 2030 vision
- Creating a list of immediate suggestions how to promote the energy and climate vision.
- + Desired effect: empowering and networking the participants in advancing the energy transition.

Outputs

A report with:

- A description of a vision, change principles and drivers
- Descriptions of transition paths
- Lists of immediate measures
- Suggestions of experiments, their timing and interconnections
- Table with suggested measures for different actors
- Process evaluation
- A possible platform/list through which the participants and organisers may continue

Some success

- 2017 transition arena report was handed over to Cabinet Minister
- Discussed in a panel of four MPs and head of “Business Finland”
- Featured in headline TV news and was covered by 16 newspaper articles in major Finnish media.
- Over 30 blogs and columns
- Its discussion in social media received over 150 comments in “new energy policy” discussion group
- Discussion invitations to key energy system institutions in 2018: Federation of technology industries, Ministry of Employment and Economy, Largest energy company…

Conclusions

1. **Energy transitions are more than just diffusion of renewable energy technology**
   - Changes in business models, policies, and practices – resulting in a systemic shift
2. **Sustainability transition approaches aim to (1) explain how system transitions happen and (2) explore the ways we can accelerate them**
3. **Fore core approaches with slightly different focus**
   - Transition management: a normative approach (i.e. toolkit) to facilitate transitions through vision building and experiments
   - Multi-level perspective & strategic niche management: broad interrelated approach for explaining how transitions happen (with some implications for policy makers for developing right kind of strategies and instruments)
   - Technological innovation systems: focused on explaining and supporting the build up and diffusion of new (sustainability) innovations

Discuss

- **What do you see as the most interesting concepts & approaches? Why?**

- **Select one of the 4 core approaches and think what practical use it could have:**
  - For a specific energy issues/technology
  - For a particular actor group (e.g. a start up, incumbent energy business, a civil servant, an NGO)