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# Transitions to sustainability: a complex systems approach

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22-06-2009, Lisbon



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# Structure

1. Transitions and System Innovations
2. Complex Systems Approach
3. Empirical Examples
4. Relations with Industrial Ecology
5. Future Agenda



# Crisis

current crisis is a systems crisis

financial crisis is symptom of systems crisis

systems crisis is rooted in

production/consumption

exhaustion natural resources

current economic order is non sustainable



# Crisis

IEA (International Energy Agency)

World Energy Report 2008

“ We are facing a global energy crisis. This energy crisis is related to the climate crisis. To limit the global warming to 2°C we need an energy revolution. This implies a massive transition from conventional energy sources as coal and oil to sustainable sources as wind and solar (and nuclear energy....) ”



# Crisis

three levels of analysis:

1. financial and banking crisis

financial supervision and regulation

2. relations market, government and society

limited market forces, role of government and civil society

3. virtues, norms and values

new economic order in light of the energy/ climate crisis

*moral crisis: window for new, sustainable economy*



# Period of transition

crisis is manifestation of systems transition

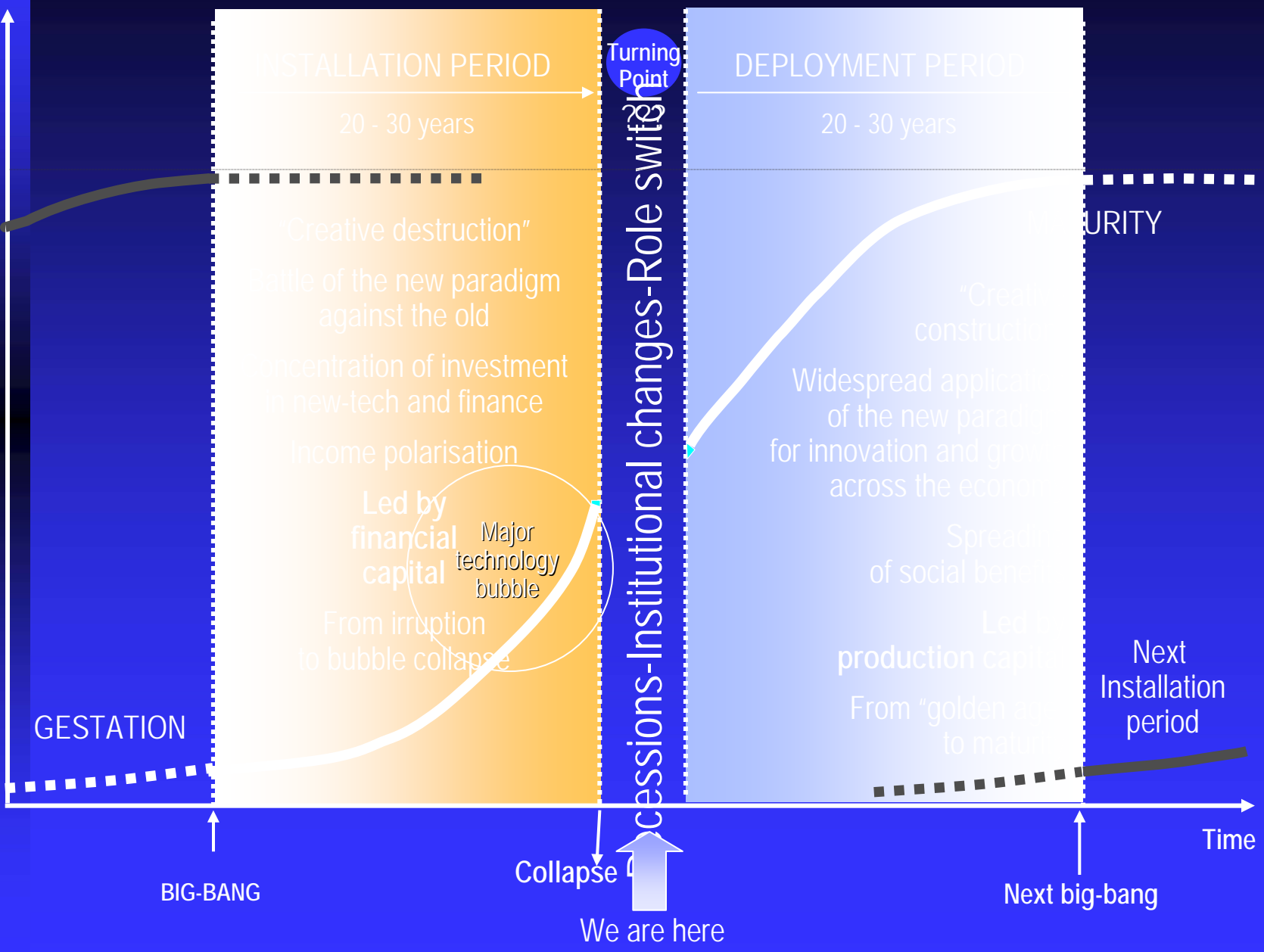
“ Within one generation many people lost two value systems: religion and ideology. This gap has not been filled by an alternative value system yet. We live in transitional times in search for new value systems. This goes along with turmoil, uncertainty, lack of confidence, fear and impotence ”

crisis is the chance for an upheaval of the system



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Due to the difficulty of social absorption of revolutions and new paradigms  
EACH GREAT SURGE IS BROKEN INTO TWO DIFFERENT PERIODS





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# Sustainability Transitions

quest for new value systems

are we following the right trajectory, but too slowly?

or

are we following the wrong trajectory?





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# Rationale

persistent problems

system failures

system restructuring

transition

transition governance



# Persistent problems

- our society faces a number of persistent problems
- unsustainability is the symptom of the persistence of these problems
- many examples: climate change, energy supply, water problem, mobility problem, agriculture, health care
- persistence is due to system failures and requires a system break and system shift: transition



# Transition

fundamental change of structure, culture and practices in societal (sub)system

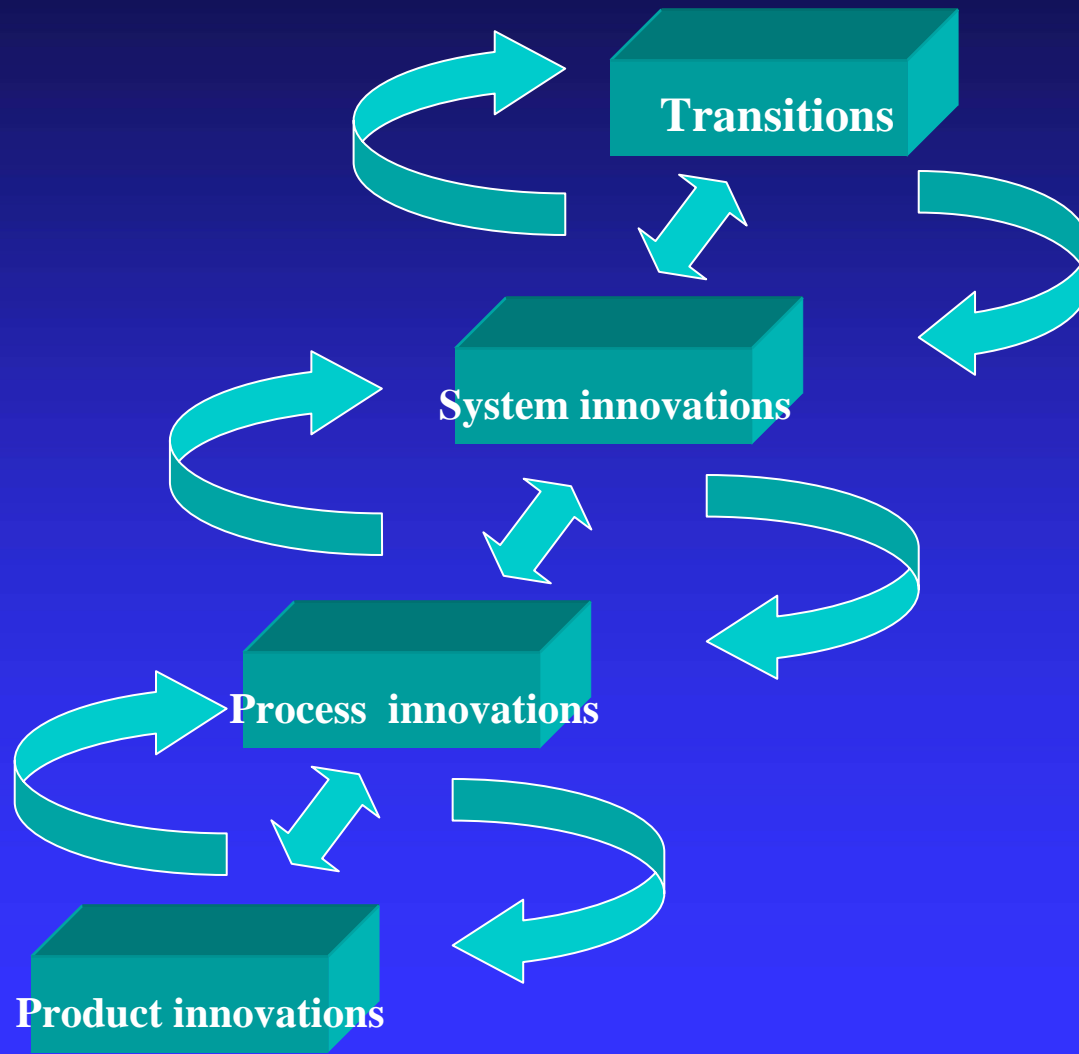
- **structure:** physical infrastructure, economic infrastructure (market, consumption, production), institutions (rules, regulations, collective actors)
- **culture:** collective set of values, norms, perspective (shared orientation), paradigm (defining problems and solutions)
- **practices:** routines, behaviour, ways of handling, implementation at the individual level

incumbent structure, culture and practices are broken down, which requires time to overcome resistance



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# Cascade of Innovations





# Examples of transitions

- From coal energy supply to gas energy supply
- From extensive to intensive agriculture
- From an industrial to service economy to knowledge economy
- Demographic transition

(see: [www.energietransitie.nl](http://www.energietransitie.nl) )



# Water transition: from stemming water to accomodating water

- Strategy of Pumping-Draining-Diking turned out unsustainable *increasing pressure from land onto water and from water to land*
- This has lead to a change in perspective *from controlling water to giving water more space*
- Seed for change in perspective arose decades ago within a small group of people from outside the water world *visionaries from nature development and spatial planning*
- Implementation of transition water policy is still difficult *many practical barriers hinder implementation*



# Transition Research

*multi- and interdisciplinary*

## 1. Analysing Transitions

- *historical and contemporary transitions*
- *how and where do transitions arise?*
- *what are deeper-lying driving forces of transitions?*

## 2. Governing Transitions

- *instruments that can be used in transition processes*
- *how can we organize a transition management process?*
- *how to monitor progress and development in transitions?*



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# Analysing Transitions

using complex systems theory to

*identify, describe and explain*

transition patterns





# Complex systems theory

complex, adaptive systems:

- open, interactive systems with many relations among components
- contain emerging patterns
- have different attractors (preferred system states)
- have the ability to adjust to changes in their environment
- co-evolve with their environment
- display strongly nonlinear behaviour

*agents that interact with each other and  
adapt to other agents and changing conditions*



# Complex systems theory

emergence, co-evolution, self-organization

- emergence
  - interaction between systems lead to irreversible patterns of change within each of the systems
- co-evolution
  - the arising of new structures and patterns within systems
- self-organization
  - ability of systems to organize themselves without external direction of control



# Complex systems theory

variation, selection, diversity, heterogeneity

adaptation means continuous variation and selection

mostly dynamic equilibrium with selection as dominant mechanism

sometimes instable and chaotic periods (punctuated equilibria)  
in which variation is dominant mechanism

system variation can be expressed in diversity and heterogeneity

diversity of components, of relations, of system behaviour



## Complex, adaptive systems cyclical patterns of change

system develops into the direction of a certain attractor, and settles in a dominant regime: a dynamic equilibrium with many mutations but a relatively stable structure

gradually the system alienates from its environment, till it reaches a critical point at the cutting edge of two attractors, onto a new dynamic equilibrium, etc. Or the system cannot adequately respond to these radical changes and dies.

so relatively long periods of equilibrium, order and stability are alternated with relatively short, shock-wise periods of disorder, instability and chaos: punctuated equilibria



# Multiple transition patterns

generic patterns as sequences of mechanisms

- regime: dominant structure, culture and practices with power at systems level
- niche: upcoming, diverging structure, culture and practices at lower scale level
- mechanisms: processes or events, such as variation and selection, adaptation, emergence, clustering, empowering
- pattern: built up of mechanisms and a manifestation of such a pattern is a pathway
- pathway: sequence of patterns



# Niche-Regime interactions

regime will try to maintain and defend its existing power and will try to eliminate or assimilate niche-regime

regime has diverse defence mechanisms in the form of resistances: institutional, governance, technological, economic and social resistance

especially newcomers (niches), together with 'change-inclined' regime actors can break through the existing order and structure

transition = regime-shift = shift in power



# Three key transition patterns

- (i) *bottom-up pattern*: niches emerge outside the regime, cluster and form a niche-regime that attacks the incumbent regime which ultimately is transformed into a new regime
- (ii) *internally induced pattern*: niches emerge within the regime and form a niche-regime within the incumbent regime that gradually incorporates the niche-regime and evolves into a new regime
- (iii) *top-down pattern*, where a massive, fast change in the landscape leads to a striking pressure on the regime that results in a regime-change

*De Haan and Rotmans, 2008*



# Building blocks of transition patterns

Mechanisms [ creation, co-evolution, clustering ]

Conditions [ tension, stress, pressure ]

Pattern [ reconstellation, empowerment, adaptation ]

reconstellation = top-down constellation change

empowerment = bottom-up constellation change

adaptation = internally induced constellation change

Pathway = sequence of patterns

Chains of transitional change





# Health care case study

Constellation ↓	Period / Pattern (Condition) →		
General practice		<p><b>1865 Reconstellation (Stress)</b> The Thorbecke laws define and protect the title "physician". This limits authorisation to practice medicine and thus general practice to those having passed a state exam.</p>	<p><b>1912-1930 / Adaptation (Stress)</b> Internal struggles in the medical association lead to positioning of specialists with respect to general practitioners and steps to a system of referral.</p>
Mental health	<p><b>1818-1883 / Reconstellation (Tension)</b> Enlightenment and French revolution inspire laws distinguishing the sick, the mentally ill, vagabonds and criminals formally. Incarceration of mentally ill in penitentiary institutes is prohibited.</p>	<p><b>1850-1900 / Adaptation (Stress)</b> Asylums become more like hospitals under the "somatic approach": being treated similarly as having a physical illness, in the sense of treatment in bed. Under the stress of overcrowded asylums and natural scientific success.</p>	<p><b>1920-1950 / Adaptation (Tension)</b> Medicalisation and deinstitutionalisation. New mental illnesses recognised (like schizophrenia). Patients treated more and more like in a hospital in the sense of brief stays.</p>
Pharmacy		<p><b>1841-1865 Empowerment (Tension)</b> Pharmacists unite in the Dutch association for pharmacy (NMP) when the state committee to investigate new healthcare legislation is summoned. Their lobby secured the position of the pharmacist as a medical profession in the 1865 laws.</p>	<p><b>1914-1930 / Adaptation (Tension)</b> Isolation in WWI and post war boom in chemical industry make large scale industrial production of pharmaceuticals possible.</p>
Specialists		<p><b>1850-1930 / Adaptation (Tension)</b> Progress of medical science in saw growth of number of specialists and their becoming a group within the medical community.</p>	<p><b>1865-1878 / Reconstellation (Stress)</b> Necessity to order healthcare and higher education leads to Thorbecke and education laws. More recognition for specialists and more educational possibilities to become one (HBS).</p>
Hospitals	<p><b>1818-1854 / Reconstellation (Stress)</b> Legislation comes into effect that makes hospital a place for the sick (no longer as a place for temporary lodging for instance) and municipalities become responsible for the healthcare of their poor.</p>	<p><b>1848-1920 / Adaptation (Tension)</b> A new spirit ("reveille") and the new constitution banning repression of the Catholic community leads to the founding of many new hospitals (Deaconess, Catholic and private).</p>	<p><b>1860-1900 / Adaptation (Tension/Stress)</b> Anaesthetics, hygiene, a- and antiseptics transform the hospital into a place of nonlethal surgery.</p>



# Health care case study

## 1920-1941 / Adaptation (Pressure)

The specialists become more dominant in the hospital and the treatments it offers. Specialist bring prestige and knowledge in the hospitals and they profit of the facilities.

## 1875-1940 / Empowerment (Pressure)

Rise of the cross-organisations setting the standards for nursing and its education. Cross-organisations take a central and rather autonomous role in public hygiene and preventive healthcare.

## 1920-1940 / Adaptation (Stress)

Success and almost national reach of care given by cross-organisations give them access to government funding which introduces significant government influence.

## 1875-1940 / Empowerment (Pressure)

Rise of the cross-organisations setting the standards for nursing and its education. Cross-organisations take a central and rather autonomous role in public hygiene and preventive healthcare.

## 1941 Reconstellation (Stress)

German sick fund act ends disorderly system, institutes mandatory coverage of, amongst other things hospitalisation, introduces mandatory acceptance of patients and for patients up to a certain income mandatory membership.

## 1941 / Reconstellation (Stress)

The German sick fund act makes hospitalisation accessible for sick fund patients.

## 1950-1990 / Adaptation (Tension)

Nursing profession's societal appreciation changing, losing its emancipatory appeal, stabilising after higher educational reforms giving it a more solid basis.

## 1973-1982 / Reconstellation (Tension)

The welfare state subsumes a lot of the public health aspects of the cross-organisational work.

## 1848-1982 / Adaptation (Tension)

Several attempts to create some form of national health service all fail. Public health remains a government subsidised privately organised matter. Government takes a lot of control over the cross-organisations roughly from 1920-1940.

## 1964 Reconstellation (Tension/Stress)

The law AWBZ becomes effective arranging much of healthcare financing in three compartments: direct coverage (mental and long-term healthcare), sick funds for essential treatments and non-compulsory insurance for non-essential healthcare.

## 1982-1990 Adaptation (Tension)

Right-winged liberal governments cut in budgets. Reducing the role of the cross-organisations to home-care organisations.

## 1973-1982 / Reconstellation (Tension)

The welfare state subsumes a lot of the public health aspects of the cross-organisational work.

## 2001-2006 Reconstellation (Tension)

Reorganisations are attempted and become effective in 2006 introducing (limited and regulated) market dynamics in the system of healthcare financing.



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# Governing Transitions

using complex systems theory and governance theory  
to explore the limitations and possibilities to influence  
the possibilities to influence complex social systems  
in a more sustainable direction



# Managing complex, adaptive systems

- managing at the systems level is important
- the status of the system determines the way it is managed
- goals need to be flexible and adjustable at the system level
- managing means using disequilibria rather than equilibria
- creating space for agents to build up alternative regimes is crucial for innovation of the system

*built-in reflexivity results in adaptive and anticipatory management*



# Managing complex, adaptive systems

managing in terms of command and control is impossible

managing in terms of influencing pace & direction possible

means process of constant adapting and anticipating

## *Presumption*

*greater insight into dynamics of complex systems leads to better understanding of possibilities of managing them*



# Managing complex societal systems

societal systems behave like complex, adaptive systems

societal change is too complex to handle in terms of managing but still we have formulated a set of simple rules how to influence societal change

identify patterns and mechanisms of transitional change

*reflexive planning rather than social engineering*



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# Transition management

empower niche agents by providing innovation space

build up alternative power regime

searching, learning and experimenting



# Transition management

## Guiding Principles

- stimulate niches at the micro-level (*variation*)
- interconnect niches with same direction (*emergence*)
- develop visions at macro-level that can act as guidance for niche-development (*new attractors*)
- stimulate forming of niche-regimes (*selection, scaling up*)
- further modulation between macro-micro level (*co-evolution*)





# Complexity characteristics translated in principles TM

Complexity characteristics	Theoretical Principles TM	Systemic Instruments for TM
emergence	creating space for niches	transition arena
dissipative structures	focus on frontrunners	transition arena and competence analysis
diversity and coherence	guided variation and selection	transition experiments and transition pathways
new attractors, punctuated equilibria	radical change in incremental steps	envisioning for sustainable futures
co-evolution	empowering niches	competence development
variation and selection	learning-by-doing and doing-by-learning	deepening, broadening, scaling up experiments
interactions, feedbacks	multi-level approach multi-domain approach	complex systems analysis
patterns, mechanisms	anticipation and adaptation	multi-pattern & multi-level analysis



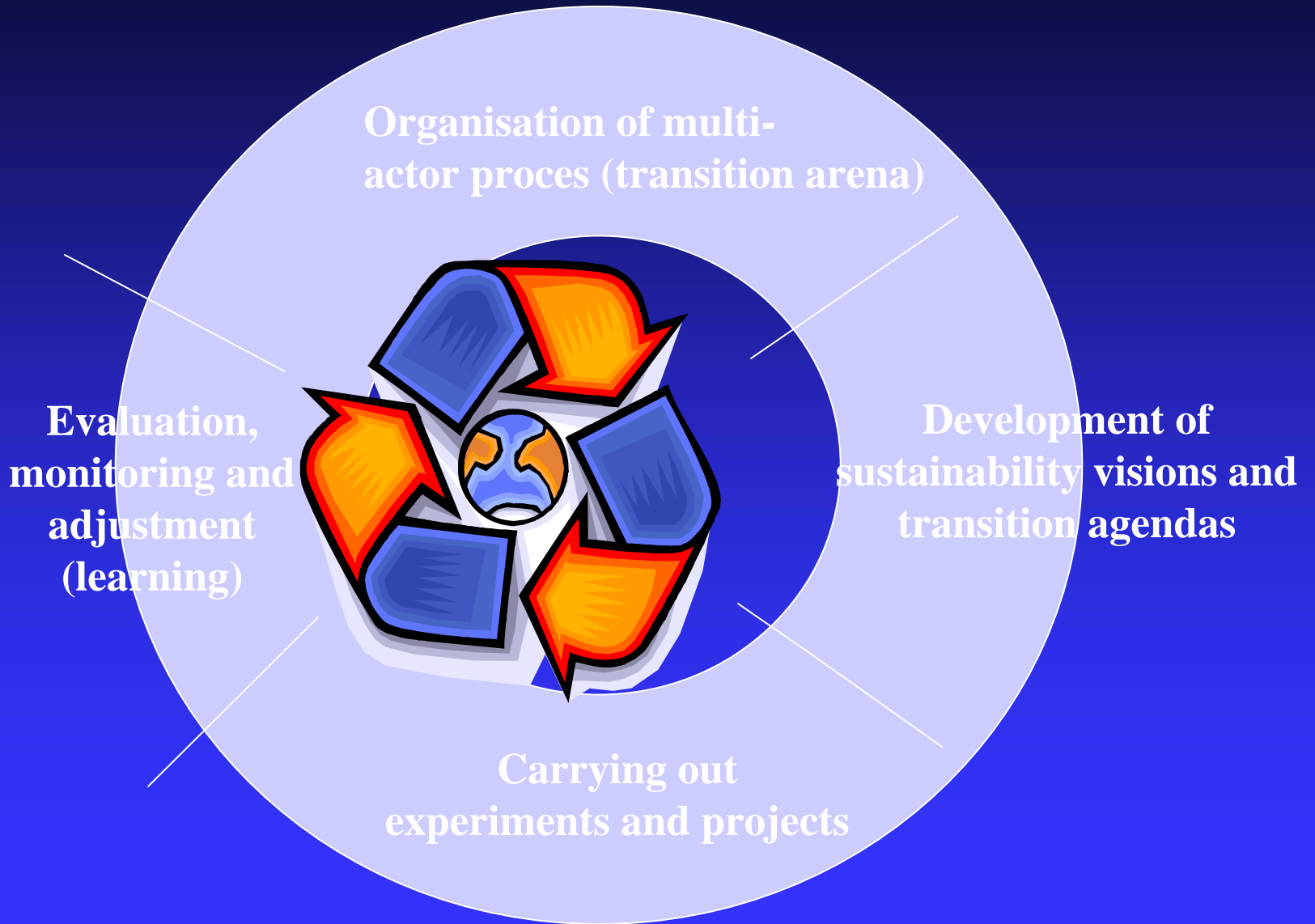
# Transition management approach

- put energy in forerunners (niche-players) and not in peloton
- bring niche-players and regime-players together in arena's
- develop a shadow line within arena's
- make it concrete as soon as possible with experiments & projects
- create movement out of new coalitions/networks
- build up societal pressure through movement



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# Transition management approach



Organisation of multi-actor proces (transition arena)

Development of sustainability visions and transition agendas

Carrying out experiments and projects

Evaluation, monitoring and adjustment (learning)



# Common Language

## Transition speak

niches	regime	niche-regime
transition patterns		transition pathways
transition visions		transition scenarios
transition arenas		transition experiments
deepening	broadening	scaling up
frontrunners	peloton	regime players
transition monitoring		transition evaluation
<i>transitionizing</i>		



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# Empirical basis in the Netherlands

national

*energy transition*

*health care transition*

regional

*city transition*

*region transition*

local level

*poor districts*

*50 transition processes*



# Empirical basis abroad

- in Belgium two transition processes are running
  - Sustainable housing, sustainable energy & materials
- in Australia big transition city program is running
  - City transition including 5 major cities in Australia
- in Finland transition health care policy attempt
- in Austria environmental transition policy attempt
- in Japan first attempts with transition experiments
- in Canada growing interest for transition policy



# Energy transition

- in 2001 initiated by the ministry of Economic Affairs (EZ)
- started with a niche (small group of frontrunners within EZ) evolved into a movement with companies, NGOs, knowledge institutions and individuals
- vision has been developed [‘where do we want to go?’]
- 7 main themes chosen [platforms or arenas]
- 28 transition paths formulated [‘how to go there from here?’]
- 100 transition experiments set up [‘how to implement paths?’]



# Energy sustainability vision

In 2050 the energy supply system is sustainable if it is:

- (i) clean [50% CO<sub>2</sub>-reduction; no other pollution]
- (ii) affordable [functional and energy-efficient]
- (iii) secure [reliable, guaranteed supplies]





# Energy transition management

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2050  
2020  
2008  
Now

Vision: global images

abstract

Transition paths

Strategic vision: worked out in concrete terms

Efficiency

Biomass

New gas

Research

Transition paths

IJkmoment: Go - No Go

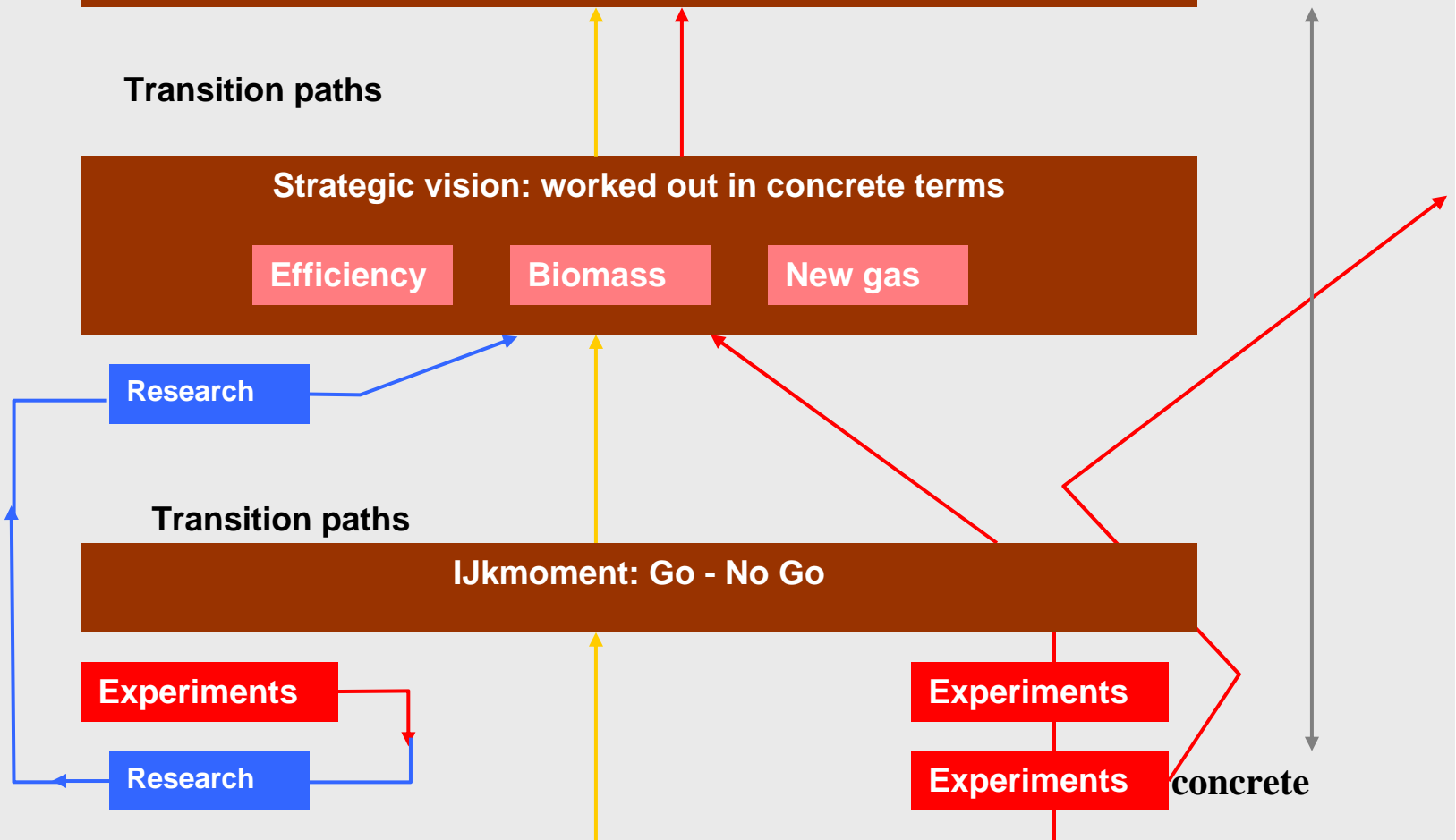
Experiments

Experiments

Research

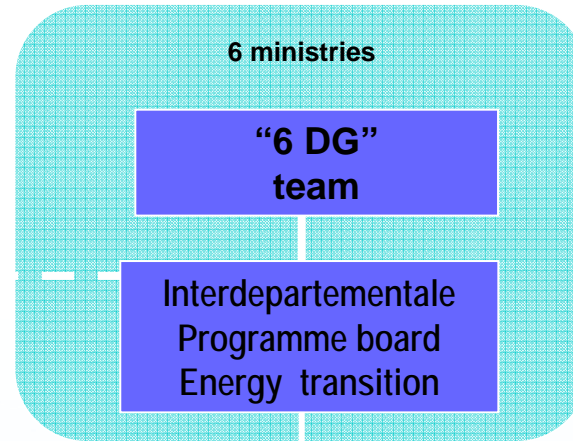
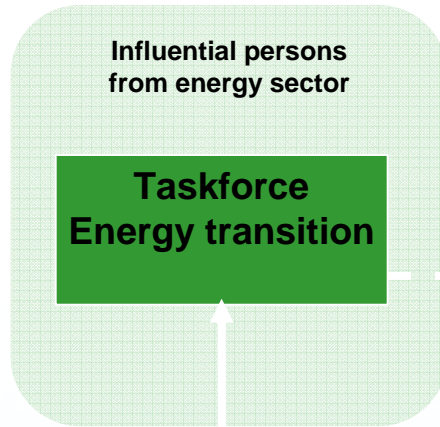
Experiments

concrete

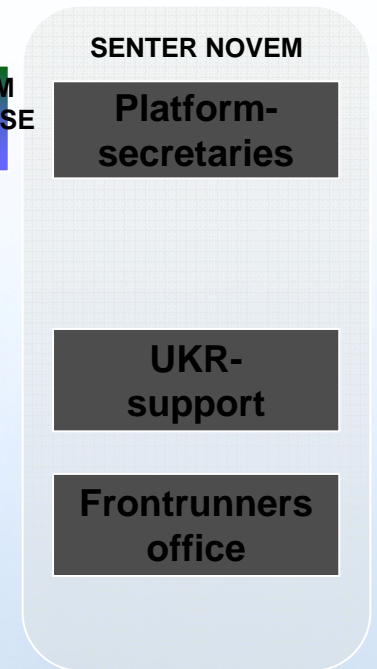


# Energietransitie

**1**  
Long-term  
vision



**7**  
Transition  
themes



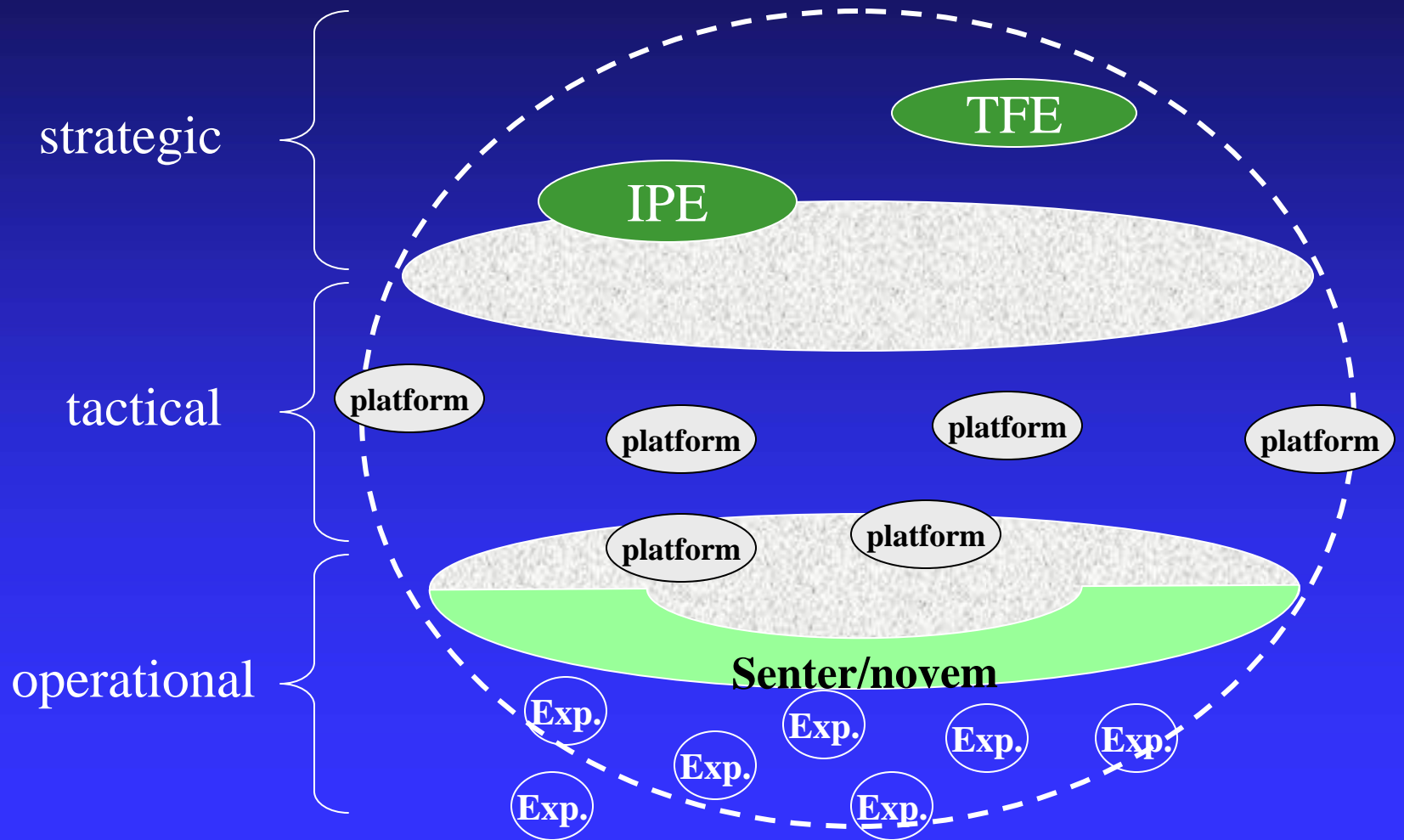
**23**  
Transition  
-pathways

**100-en**  
Transition  
experiments





# Structure energy transition





# What has been achieved?

- progress over the past five years: courage, perseverance, guts
- new discourses from broad movement with 1000 people involved
- high amount of time, manpower and energy put into the process
- reform agenda with some breakthrough projects

but

- still more regime players involved than niche players  
[Shell, Nuon, VW, Eneco]
- evolves into a practical execution process rather than  
searching, learning and experimenting



# Conclusions

- transition management seems a promising new governance mode
- we need more empirical evidence for validating the concept of transition management
- institutional and juridical entities within regime major barriers for application of transition management
- worthwhile to experiment with transition management in other countries, also outside Europe



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