Practice Theory & Complex Adaptive Systems Theory

Round table discussion on how these theories can inform future energy conservation policies

JRC – IET

26 – 27 February 2015

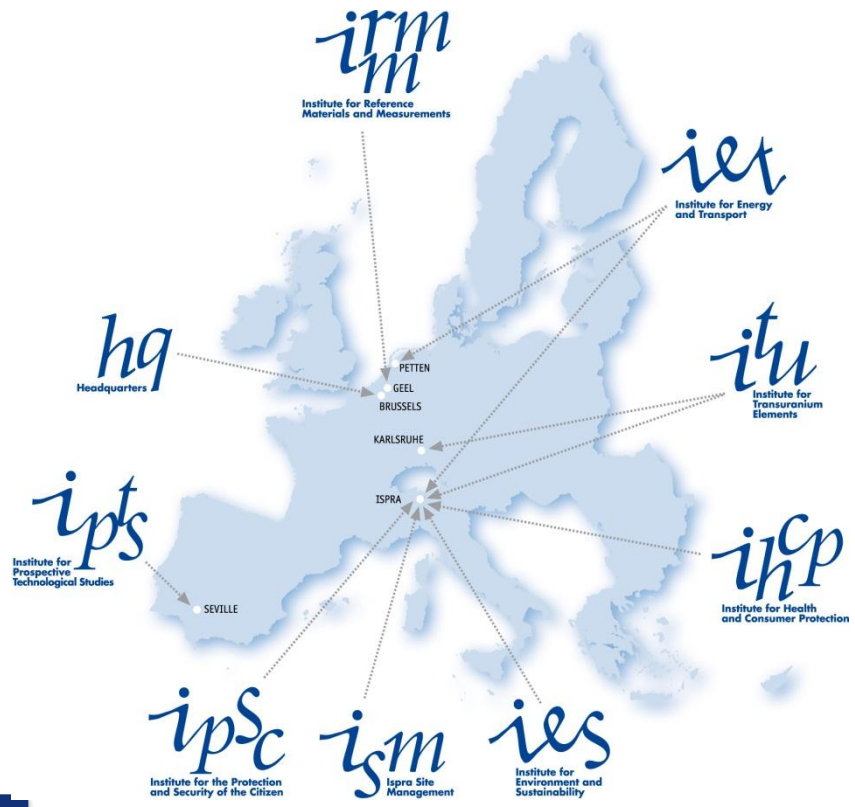
Who we are …

The JRC

European Commission

JRC is the European Commission's in-house science service
It provides independent customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.

- Established in 1957
- 7 institutes in 5 countries
- 3057 staff
- Over 1030 publications in 2014



The JRC – IET and its Renewables and Energy Efficiency Unit

European Commission

The JRC Institute for Energy and Transport

Contribution to the "Energy union & climate" priority area of the European Commission 2014-2019
Support to the 2030 climate & energy package

Some projects / activities on energy efficiency in our Unit

- *Knowledge Centre for Energy Efficiency (KCEE – LCTO – Energy Modelling);*
- *Energy Efficiency in Buildings*
- *Energy Efficiency in Urban Areas: Covenant of Mayor*
- *Energy Efficiency in Products*
- *Support to EE Directive implementation, assessment and revision*

Why we are here and what we would like to do with your support …

What we would like to do…

- Identify results and achievements that can be transposed to policy making …

- Find a way to communicate these results to policy makers and research communities operating in the energy policy field (e.g. by producing working documents, papers in scientific journals, etc.)

- Define possible types of collaboration that could allow us to advance jointly our knowledge in the identified research areas…

The dichotomous approach of current energy conservation policies (1/2)

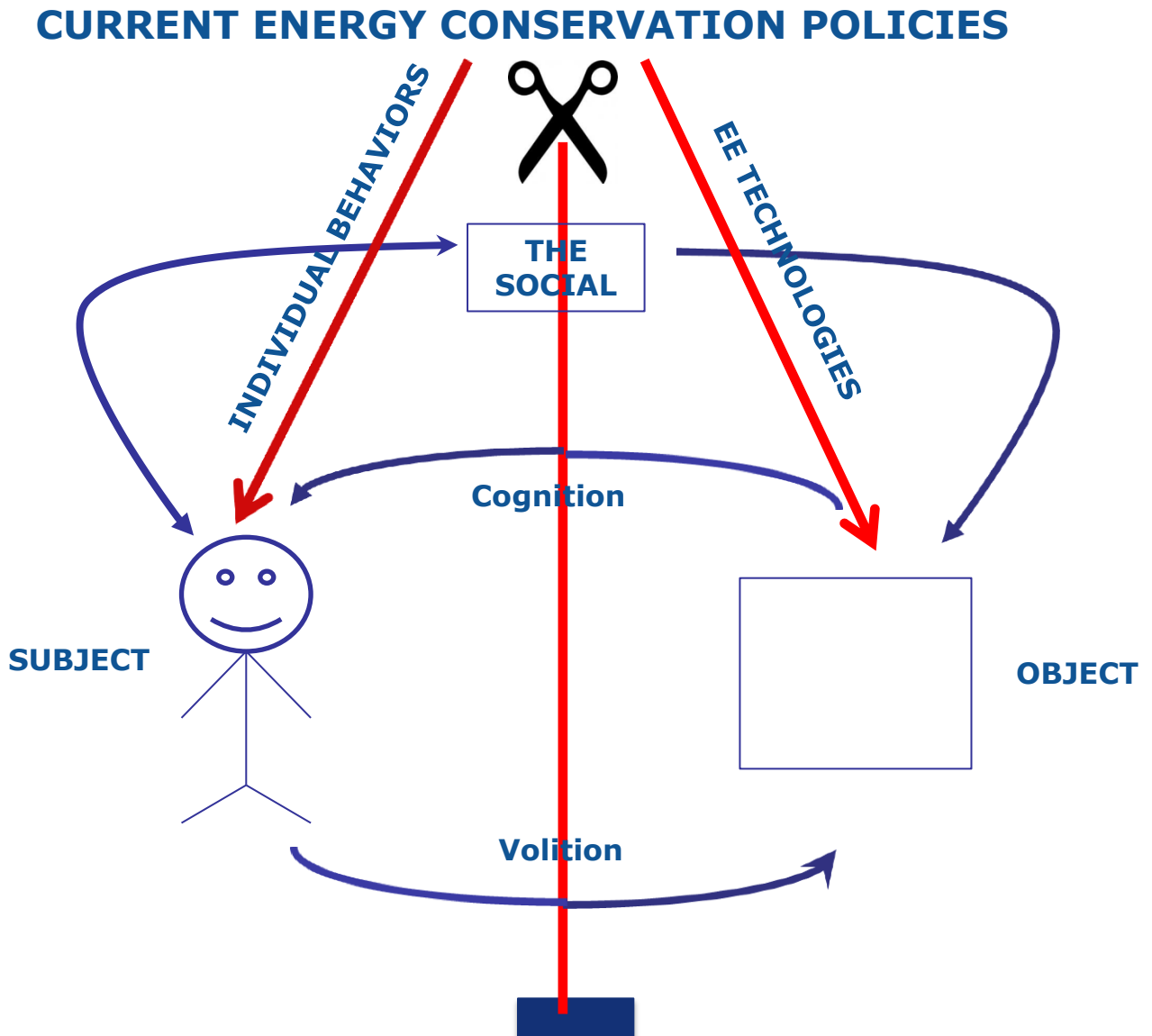
Energy conservation policies have been so far mainly informed by the concept of "homo economicus" and Rational Choice Theory

This mindset has led to the design of policies mostly targeted at:

a) manipulation of prices;

b) regulations, information camp., voluntary agreements, market-based instruments and initiatives fostering the deployment of energy efficient ***technologies*** *and* ***individual behaviors****.*

The dichotomous approach of current energy conservation policies (2/2)



Practice theory and complex adaptive systems theory can help develop a more integrated approach

Some of the main elements holding practices together

Technologies and products

Know-how and habits

Institutionalized knowledge and rules

Engagements

The main concepts of complex adaptive systems theory

Connectivity and components interdependency

Diversity

Adaptivity

Path dependency

Emergence (non-linearity)

Some of the points we would like to submit to your attention for possible discussion…

Important discontinuities occurred in the evolution of human artefacts to be taken into account....

ORGANON -> TOOL -> SYSTEM

TOOL

From XII century to 1950s

SYSTEM

After 1950s

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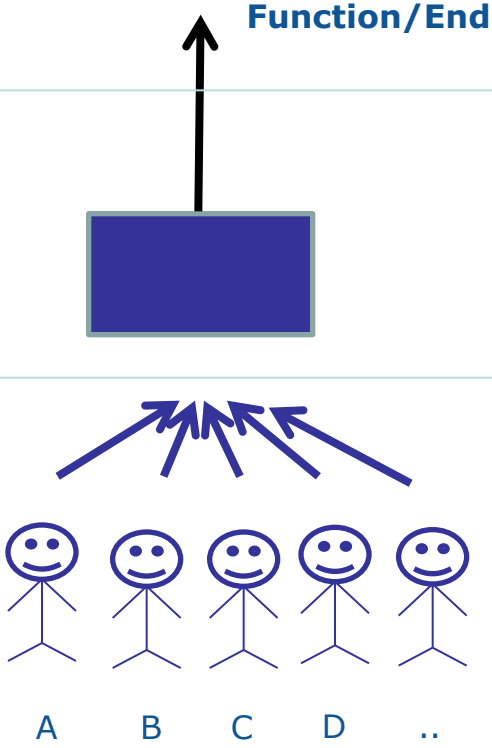
ENVIRONMENT

ARTEFACT

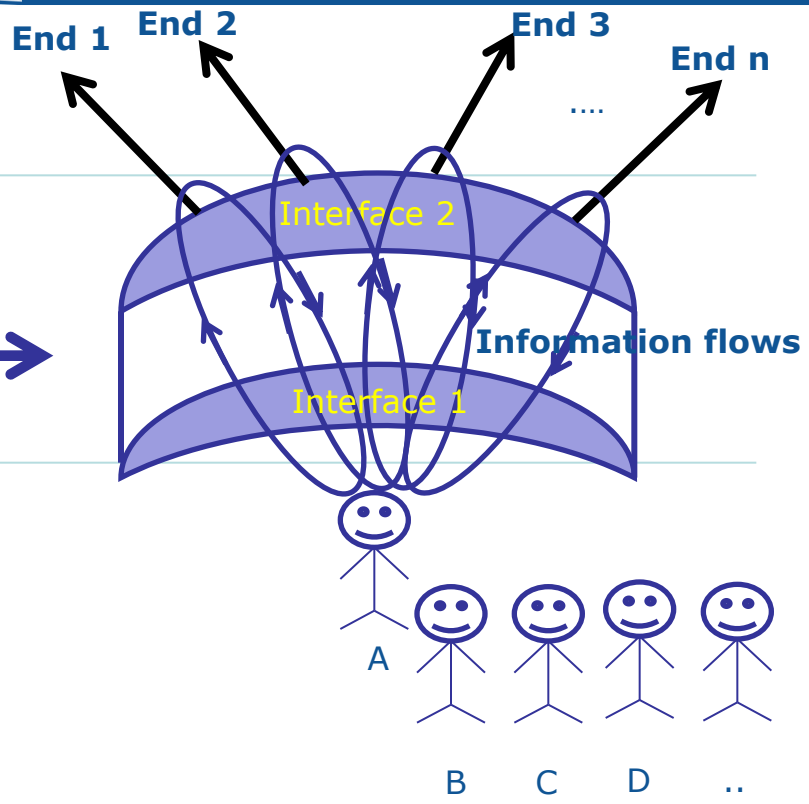
PERSON



*A specific **artefact** for a specific **end** for **any person***

Separation/distality between person and human artefact (duality)

Integration between **human artefact** and **end** to achieve



*A specific **artefact** for **multiple ends** for **any person***

Separation between ends and artefact (duality)

Integration of person and artefact into a ***system***

Which are the end-use technologies or technological sectors where practice theory can provide the most useful insights for understanding the dynamics of demand?

How and to what extent can theories of practices improve existing methodologies used to produce scenarios of future (energy) demand ?

How should design, implementation and monitoring of current energy efficiency policies be modified in order to take the findings of practice theory into account?

How the notions and analysis tools used within CAS theory can guide energy policy design and implementaion ?

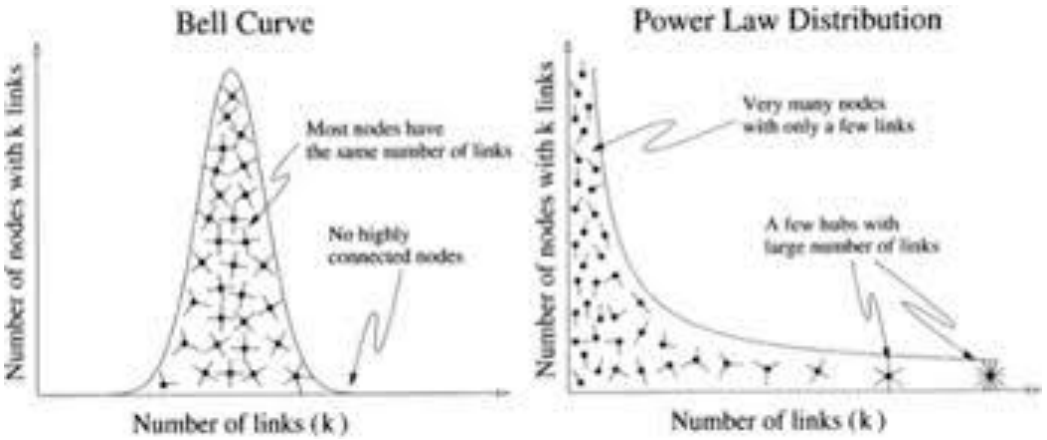
Some of the analytical tools used within complex adaptive systems theory

Computer technology

Wassily Leontief Input-Output matrixes

P_{11}	P_{12}	P_{13}	P_{14}	…	…	P_{1n}
P_{21}	P_{22}	P_{23}	P_{24}	…	…	P_{2n}
P_{31}	P_{32}	P_{33}	P_{34}	…	…	P_{3n}
P_{41}	P_{42}	P_{43}	P_{44}	…	…	P_{4n}
…	…	…	…	…	…	…
…	…	…	…	…	…	…
P_{n1}	P_{n2}	P_{n3}	P_{n4}	…	…	P_{nn}

Mathematics of Power Law Distributions



Shannon's formula measuring systems information content

$$I = k^{*}\Sigma_{ij} P_{ij}^{*}\ln P_{ij} \;\; ; \;\; \Sigma_{ij} P_{ij} = 1$$

Depending on the sytem under investigation **Pij** may represent an Energy flow ; Matter flow; Cash flow; Traffic flow; Time flow; etc.

Which are the main power law generative mechanisms that are of interest in the energy policy field?

How energy conservation policies can possibly take the presence of these generative mechanisms into account?

How do fractal (scale free) structures exhibited by complex systems conciliate with scale dependent structures usually observed in natural systems?

In which circumstances scale free structures serve to improve the sustainability of socio-technical systems?

The ambiguity of Energy and its role in sociological studies…

"**We have no knowledge of what energy is** .
. . energy is an abstract thing in that it does not tell us the mechanism or the reasons for the various formulas" Richard Feynman (1963)

"**The energy concept has no meaning apart from a corresponding process…**
One cannot speak of the equivalence of the energy of mass and radiation unless there is some process (not necessarily reversible) by which one can get from mass to radiation… (Percy Williams Bridgman, 1961)

"**It is the theory that decides what we can observe**"
Albert Einstein cited by Werner Heisenberg (1969)

Energy vs. time (1/2)

Energy and time are closely implicated physical quantities

Energy would not be of any practical use if it would not be assumed to obey a **conservation principle**

However the **energy** of an isolated system **can always be defined up to an additive constant.**

What can be measured and be properly defined is not energy.

What can be measured is a **flow, a variation of energy ($\Delta E/\Delta t$)** in a part of an isolated system when the energy of the remaining part of this system varies by **($-\Delta E/\Delta t$)** within a specific **transformation process.**

Energy vs. time (2/2)

Energy conservation is a consequence of **time homogeneity**

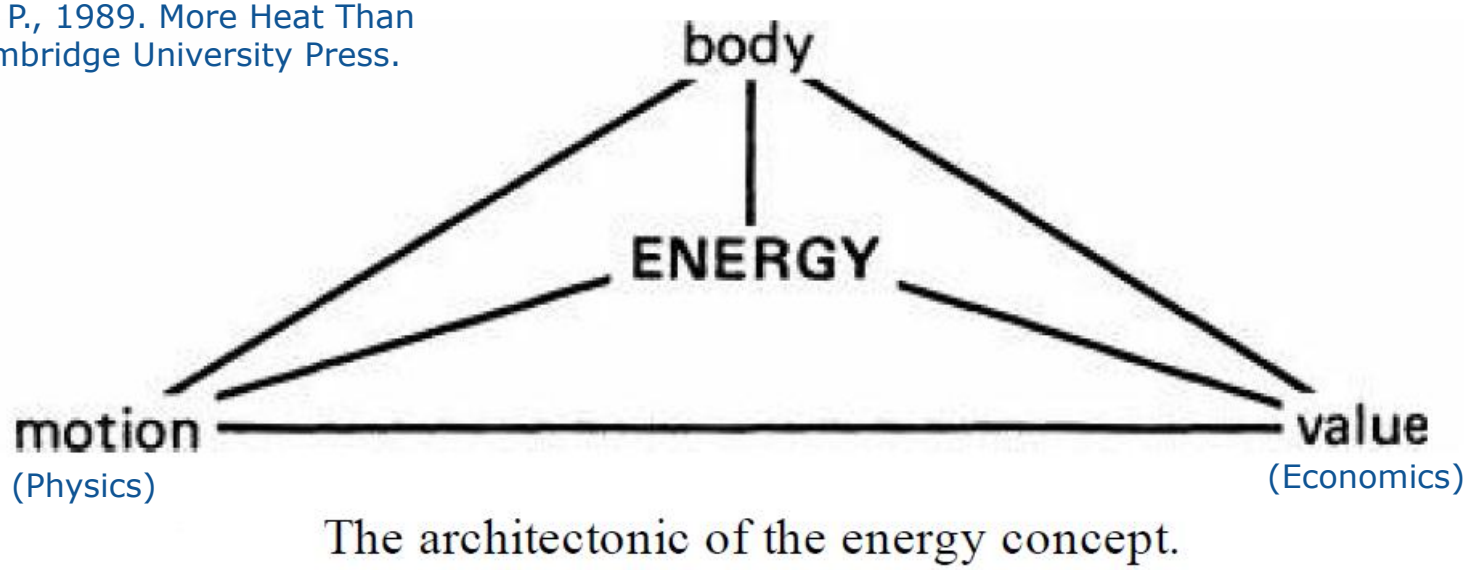
Can it be assumed that **time is not necessarily homogenous** within not isolated systems exchanging energy flows with the external environment?

Can the different sources used to generate final energy energy entail a different relationship with time? *(renewable vs. non renewable energy sources).*

Homeomorphisms among research programs…

(Anthropomorphics/biology)

Mirowski, P., 1989. More Heat Than Light. Cambridge University Press.



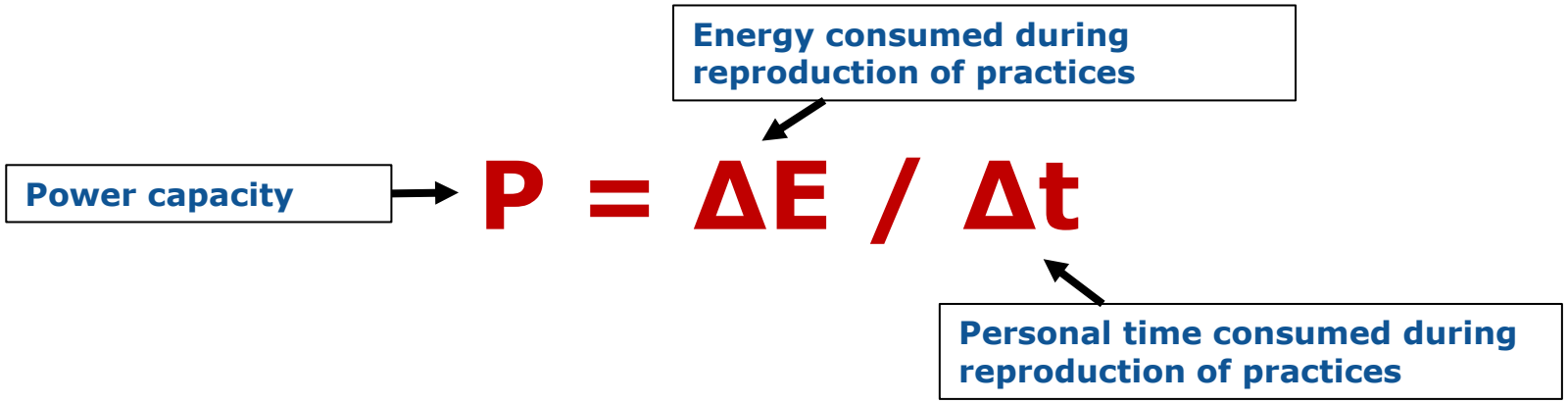
The architectonic of the energy concept.

*The **metaphor** that synthetizes the research program at each vertex **is essentially the same metaphor**.*

*The **research program** situated at each vertex **derives legitimacy** for its radically unjustifiable conservation principles **from the homeomorphisms** with the structures of explanation at the other vertexes.*

Which insights for energy policies might come from the possible presence of homeomorphisms between biology, physics and economics?

Power capacity and disembodiment



Three types of delegation processes/disembodiment:

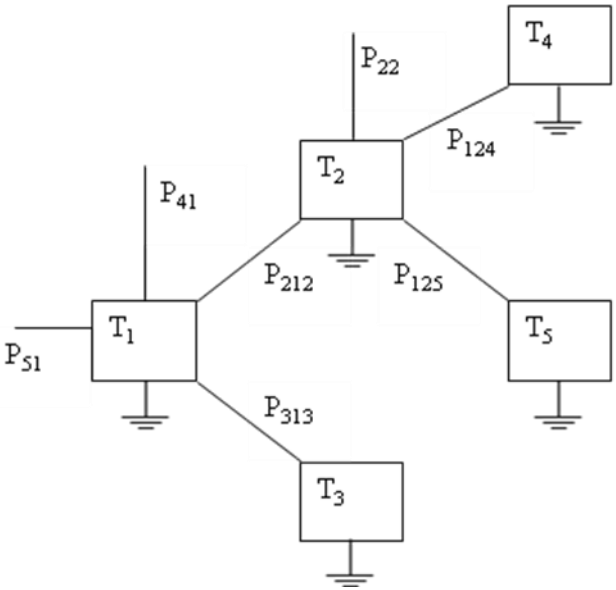
1) **Automation** (No personal involvement besides machine activation and maintenance)
2) **Increased personal capacity** to produce outputs **associated with a specific task** (e.g. kms travelled)
3) **Increased personal capacity** to produce outputs **associated with multiple tasks** (prosthetic function of systems).

Can the notion of "disembodiment" serve to develop energy policy approaches which better fit persons and their embodied knowledge?

Can the notion of "(energy) metabolism" serve to link CAS and practice theory ?

How this notion can be used to guide the design and the implementation of energy conservation policies?

Complex Adaptive Systems as a network of practices and embedded technologies (1/2)



Legenda:
Ti: technology n. i
Tj: technology n. j
Pkij: practice k involving Ti and Tj

Technology

Practice

Tools for food cultivation

Food cultivation

Motor bike

Public transport

Shopping

Car

Food procurement

Refrigerating appliances

Food storage

Meals Consumption & kitchen tools maintenance

Dish washer

Meals preparation

Cookers

Example of food preparation and consumption practices

Complex Adaptive Systems as a network of practices and embedded technologies (2/2)

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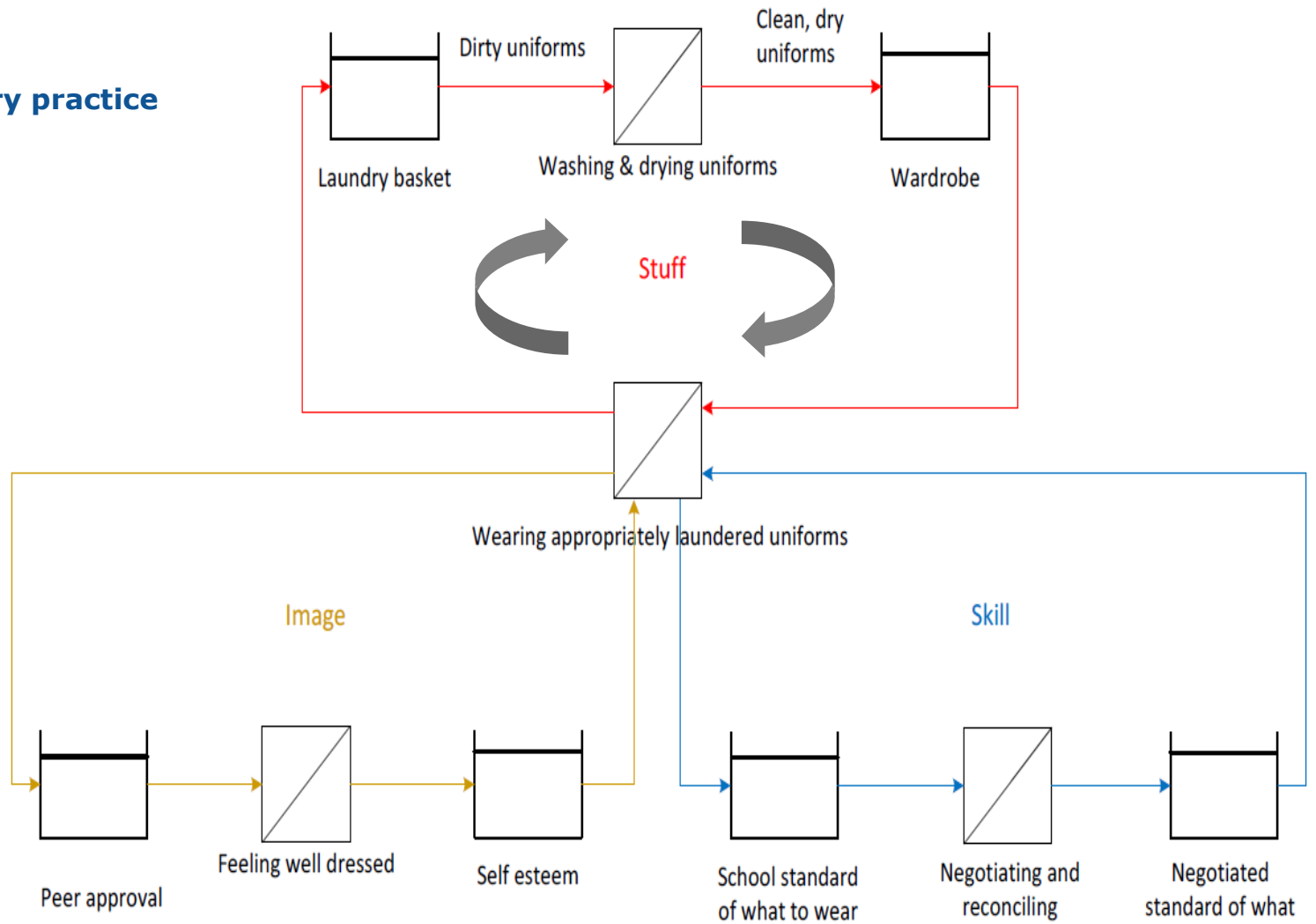
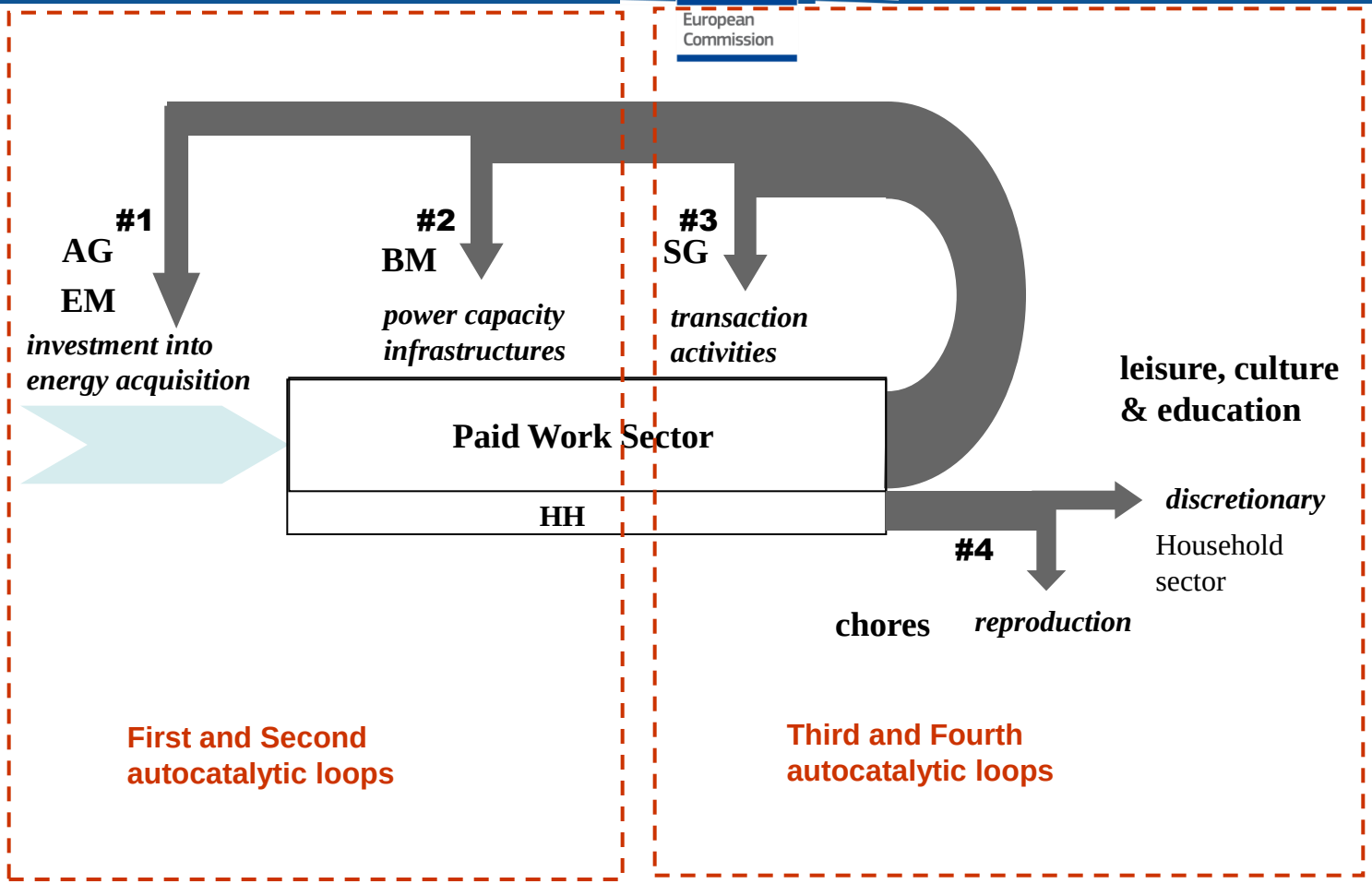
Laundry practice



Source: Higgson, S.,2014.
Can practice make perfect (model)?.
Proceedings BehaveConference, 2014.

Autocatalytic loops sustaining the energy metabolic rates at the level of whole society



Source: Giampietro, M., Mayumi, K., Sorman, A. H., 2013, Energy Analysis for a Sustainable Future.

Systems structure survival depends on the stability of an overall metabolic rate (i.e. flows of energy and material inputs and outputs) and on the stability of the metabolic rates of its parts.

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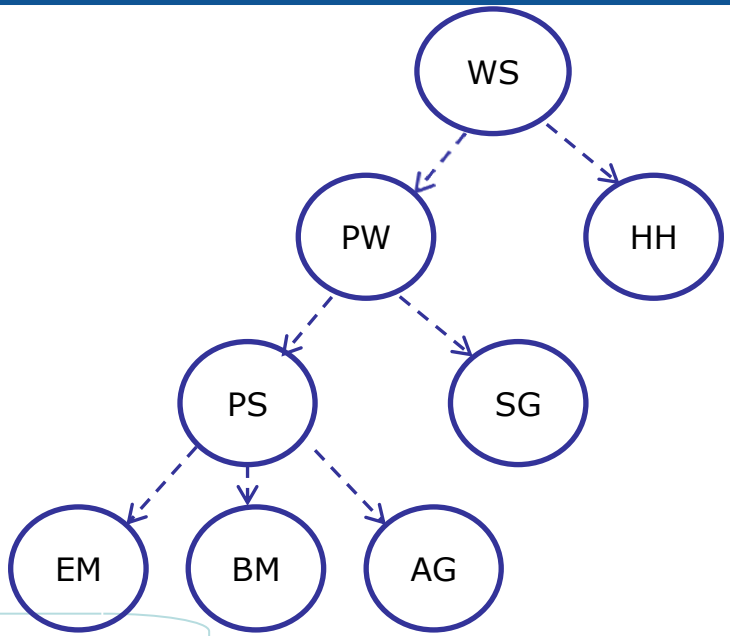
Main hierarchical levels of society exosomatic energy metabolism

SPAIN 2007	Energy *(GJ p.c./y)*	Human Activity (hrs p.c./y)	Exosomatic energy **Metabolic Rate** (MJ/hour
whole Society (WS)	**159.0**	**8,760**	**18**
Household Sector (HH)	44.5	7,825	6
Service & Government (SG)	56.5	598	94
Building & Manufacturing (BM)	41.0	280	146
Energy & Mining (EM)	13.0	8	1611
Agriculture (AG)	4.5	48	92



Paid Work Sector (PW)

Production Sector (PS)

Data and information source: Presentation held by Prof. Mario Giampietro (ICTA) at the Joint Research Centre – Ispra on 5th February 2013

How CAS theory can help adopt policy design methodologies relying on the fact that communities can devise very effective feedback protocols for the suistanable management of (energy) resource systems?

CAS theory and the Governance of the Commons

The **two** options of **early** science-based policy design methodology:

- a **top-down** environmental dictator (aka benevolent social planner)

- or **privatization** of natural infrastructures

Communities have devised very clever and effective feedback protocols relying on a trial-and-error, self-organizing, evolutionary process.

- 8 policy design principles for effective collective decision making have been derived by Elinor Ostrom

How can we evaluate what works in energy policies when we acknowledge the complexity of the social world?

How the trade-off between power capacity and energy efficiency can be taken into account to design policies improving CAS sustainability?

Existing trade-off between power capacity and energy efficiency within complex adaptive systems

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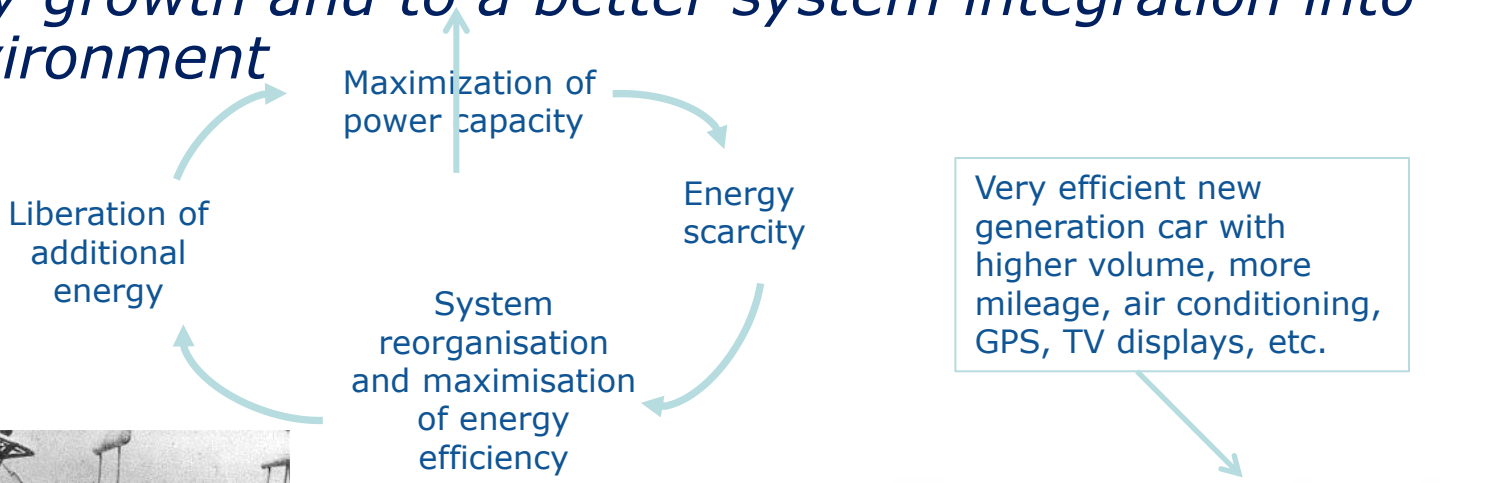
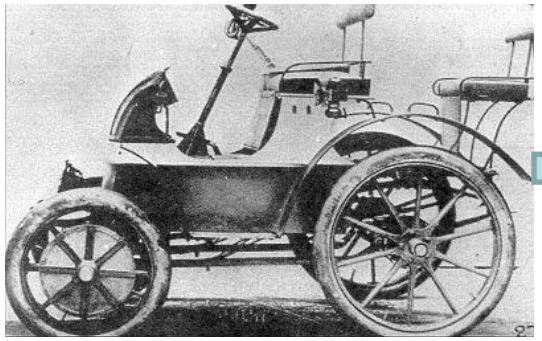
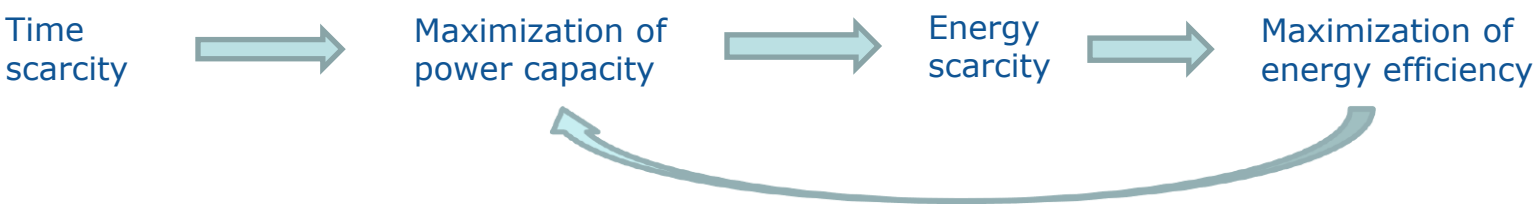
Increased systems' power capacity is the main driver of systems' evolution

Increased systems' efficiency is functional to power capacity growth and to a better system integration into the environment





The efficiency-power tension may have in principle different intensities depending on whether we act under the systems paradigm or not...



How do we enter the system paradigm when using a given material/substance?

Definition of a situation of resource scarcity

1) Operative definition of a physical quantity (i.e. the resource) and of the related metrics to assess the number of available resource units

2) Establishment of a conservation principle for this resource

3) REDUCTION of the given material/substance to a number of resource units available

4) Transformation process producing a certain number of specific and highly standardised outputs for each resource units consumed

This limits the number and the diversity of ends that can be achieved by using the given material/substance/entity !!

Is it time scarcity that determines power capacity increase or is the power capacity increase that determines an increased perception of time scarcity under the systems paradigm?

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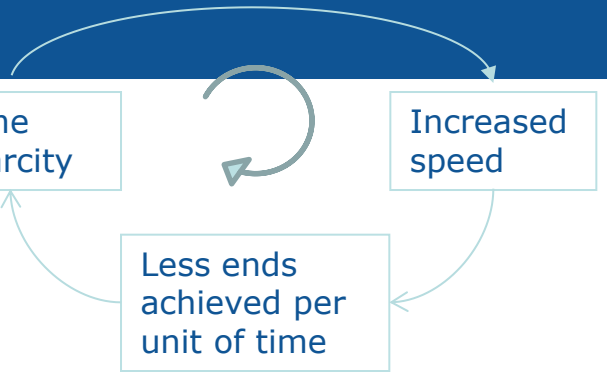
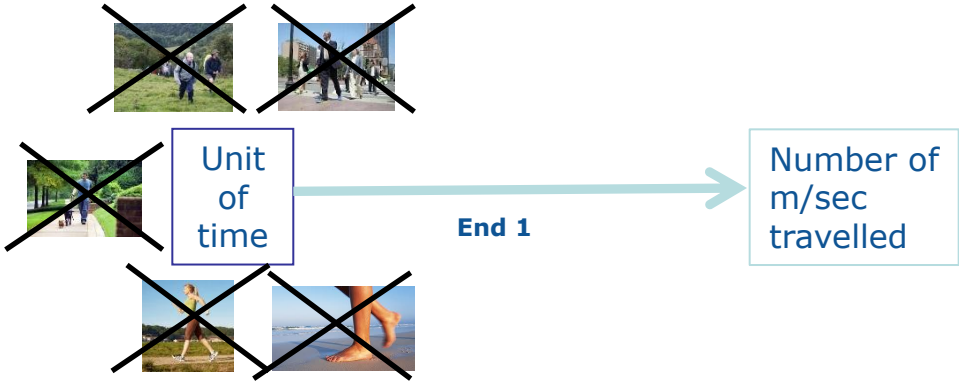
The example of speed…



HUMAN SPEED…

INCREASED SPEED BY TECHNICAL DEVICES …



Increased speed implies that a unit of time is mostly used to produce m/sec travelled and that additional time units can be needed for activities that cannot be performed while travelling by using this time unit…