

PSE/CAPE paradigm transition towards “La pensée complexe” in a global world under pressure

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June 14, 2022

<http://lgc.cnrs.fr>

Acknowledgments

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and

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June 14, 2022 - PSE and my entropy curve. A paradigm transition towards “La pensée complexe”

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PSE/CAPE paradigm transition towards “La pensée complexe” in a global world under pressure

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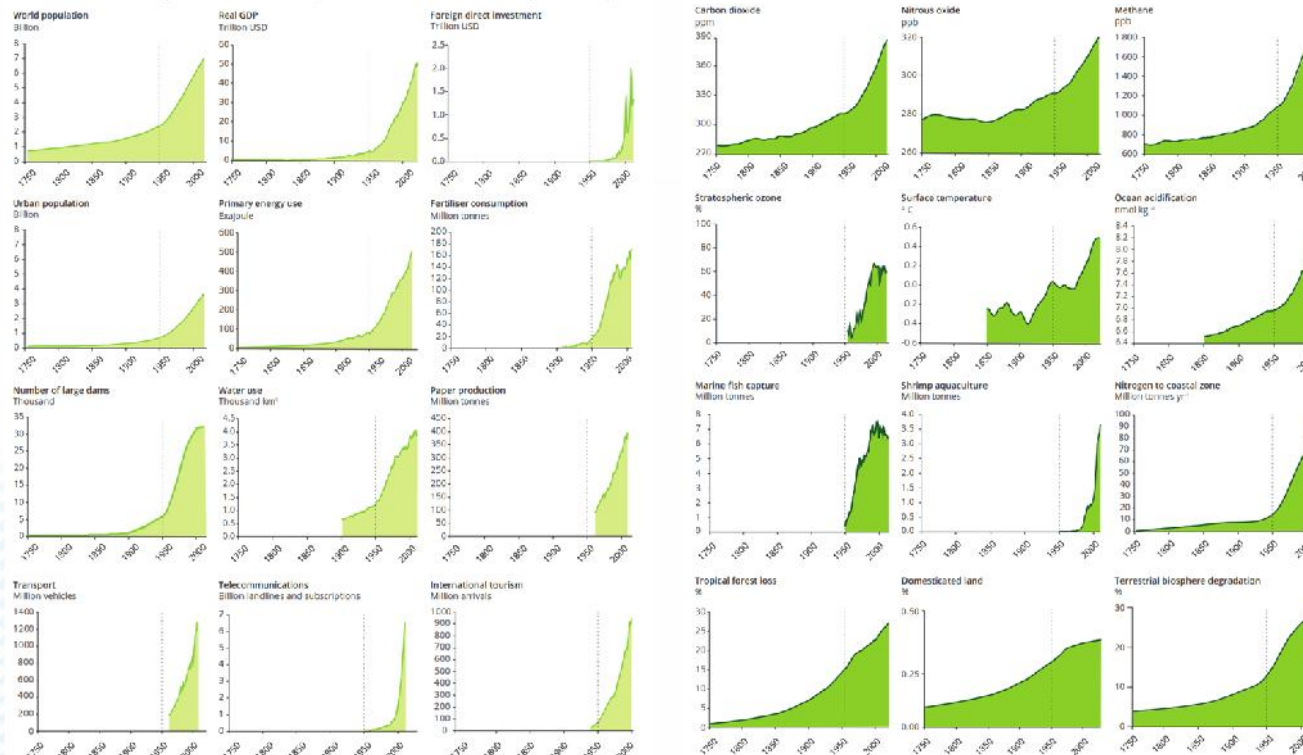
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Insatiable Humanity

- Exponentially increasing indicators for global socio-economic development and the structure and functioning of the Earth system

FIGURE 1.1 Indicators for global socio-economic development and the structure and functioning of the Earth system



Note: GDP, gross domestic product.
Source: Steffen et al. (2015b).

SOER 2020 Assessing the global-European context and trends

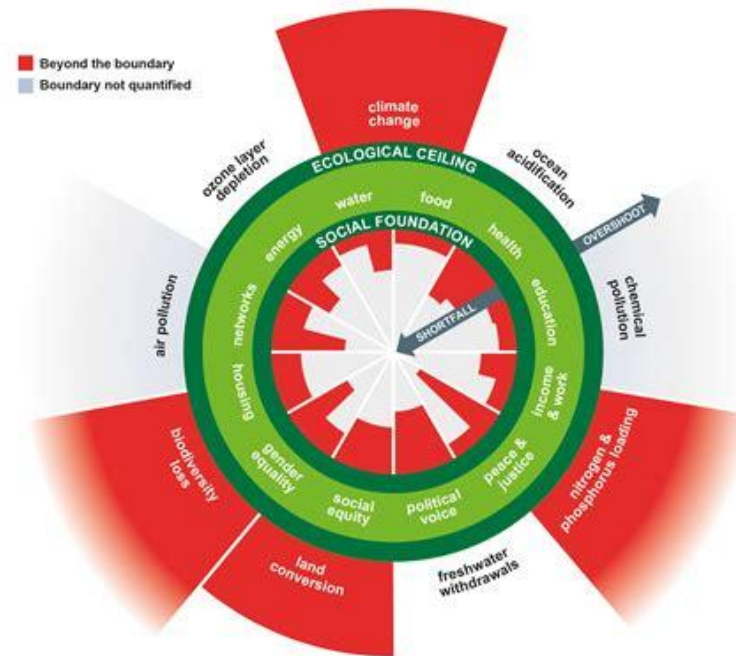
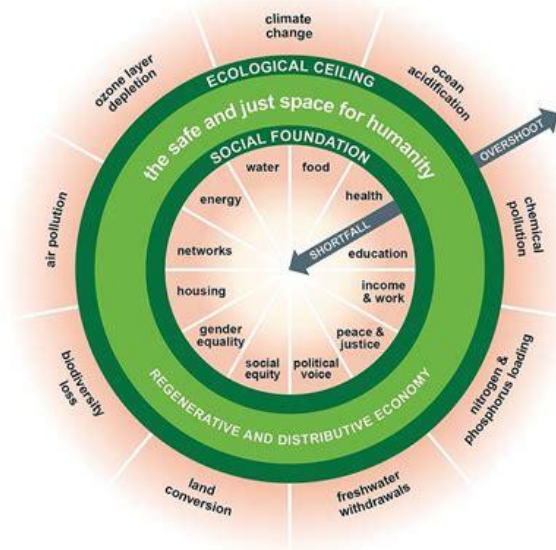
SOER 2020 Assessing the global-European context and trends 37

<https://www.eea.europa.eu/publications/soer-2020-executive-summary>



The bleak prospect

- Living safely on earth vs exceeding the liveable limits



© Kate Raworth, author of *Doughnut Economics: Seven Ways to Think like a 21st Century Economist*, 2017



The bleak prospect

- Facts and evidences are gloomy

Environment

Biodiversity

Climate



Waste (the 7th continent)



Land usage shift



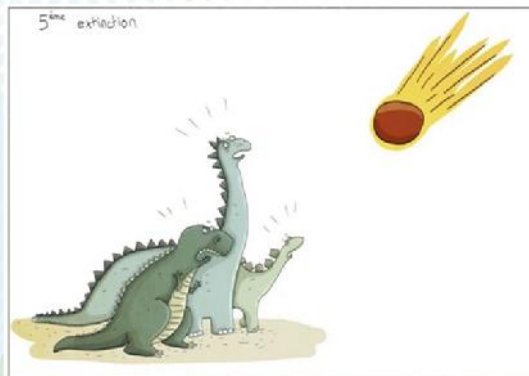
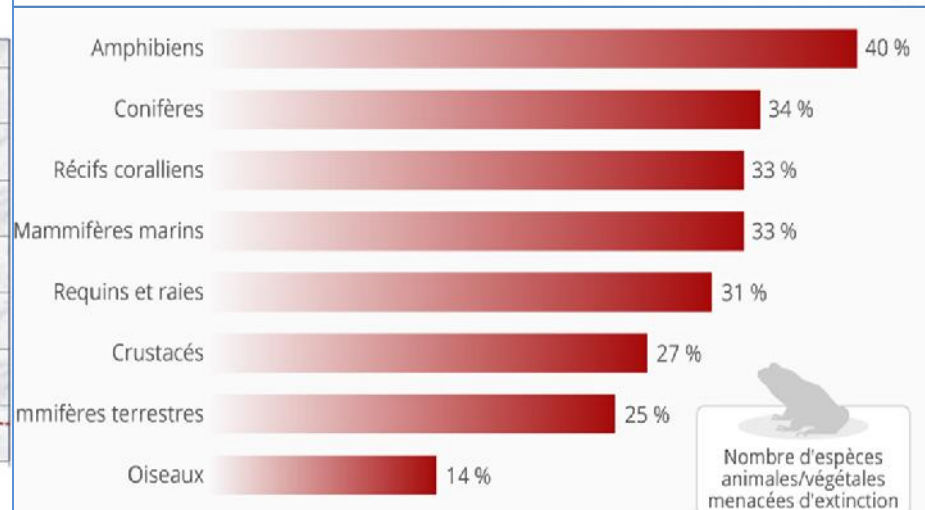
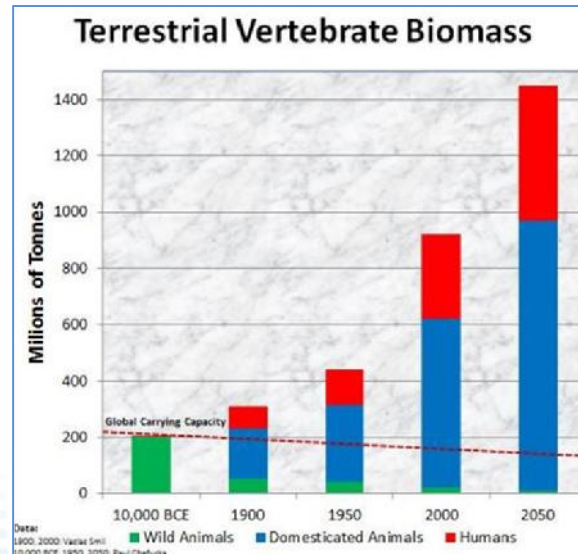
The bleak prospect

- Facts and evidences gloomy

Environment

Biodiversity

Climate



The 6th extinction

The bleak prospect

- Facts and evidences are gloomy

Environment

Biodiversity

Climate

A barely livable world

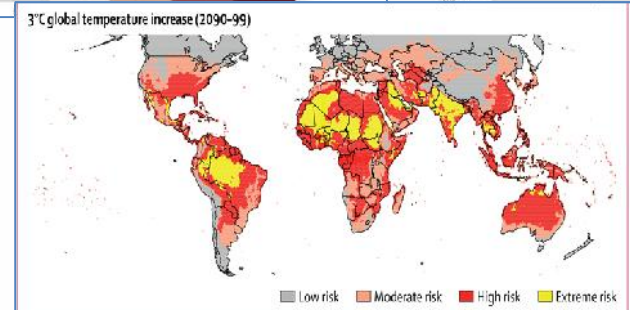
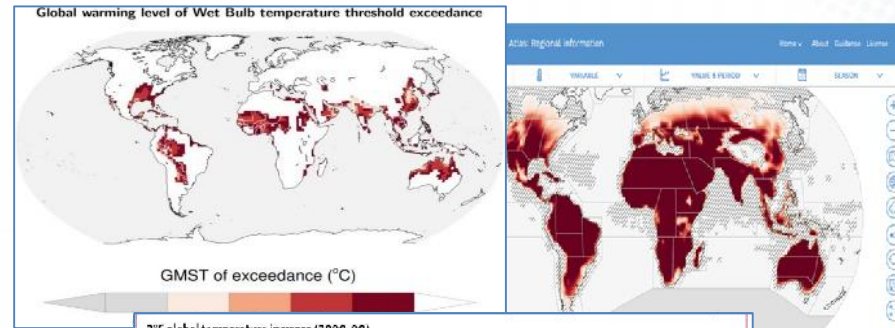


Figure 1: Global risks of occupational heat exposure in the shade during the hottest part of the day, averaged over the hottest month

La planète brûle En Sibirie, des feux de forêts démesurés



Les inondations de juillet en Allemagne et en Belgique sont bien liées au réchauffement climatique

C'est la conclusion d'une étude du World Weather Attribution (WWA), qui regroupe des experts de divers instituts de recherche dans le monde. Les pluies diluviennes survenues à la mi-juillet auraient fait plus de 900 morts.

Extreme heat in Canada and the US

Forecast temperatures to July 1



Pluie inédite près du sommet de glaciaire du Groenland, à 3 000 mètres d'altitude

Cet épisode pluvieux intervient alors que des températures inhabituelles de plus de 90 °C ont été enregistrées dans le nord du Groenland pendant l'été.



Extreme events



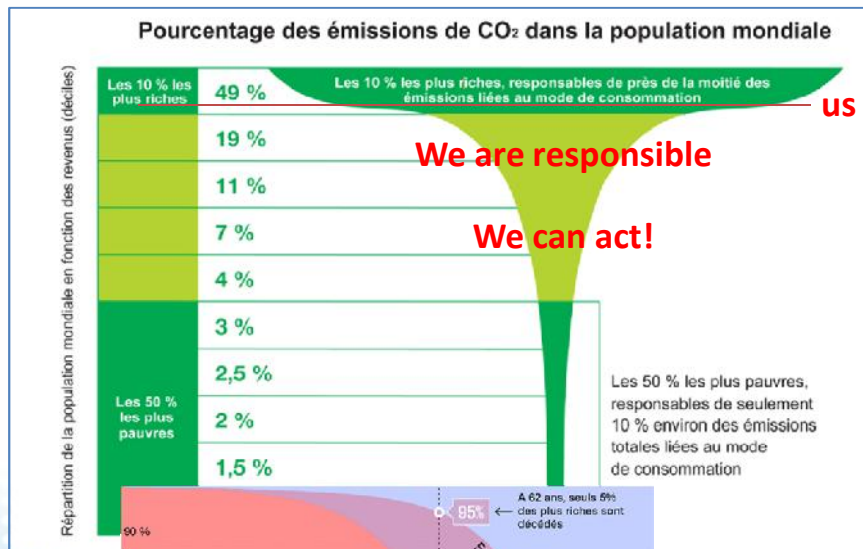
The bleak prospect

- Facts and evidences are gloomy (more)

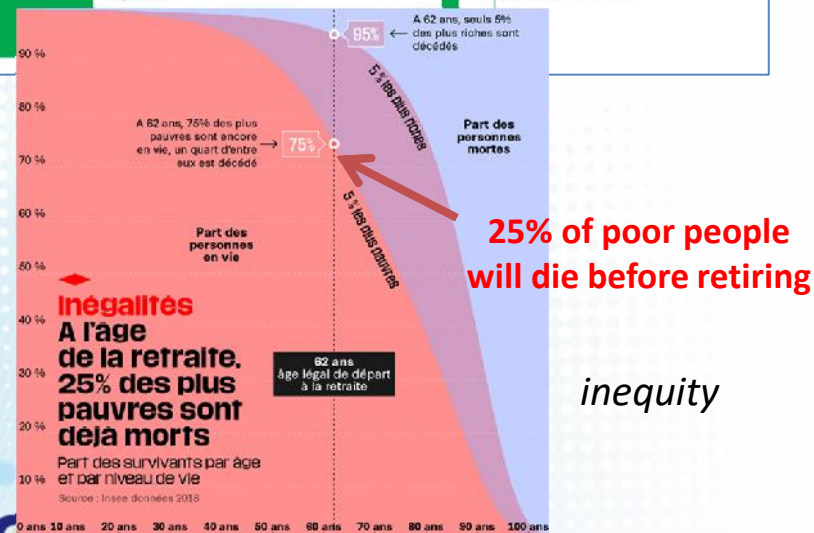
Humanity

Resources

Energy



inequality



inequity



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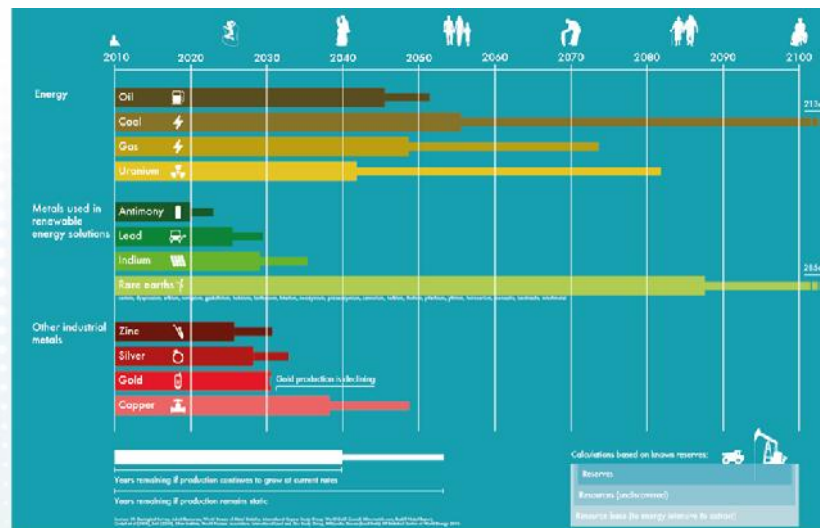
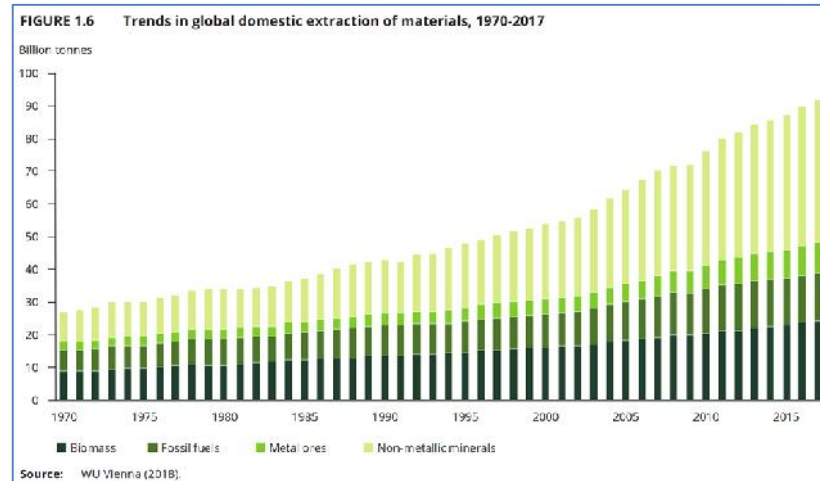
The bleak prospect

- Facts and evidences are gloomy (more)

Humanity

Resources

Energy



thirsty extraction
→ *depletion*

The bleak prospect

- Facts and evidences are gloomy (more)

Humanity

Resources

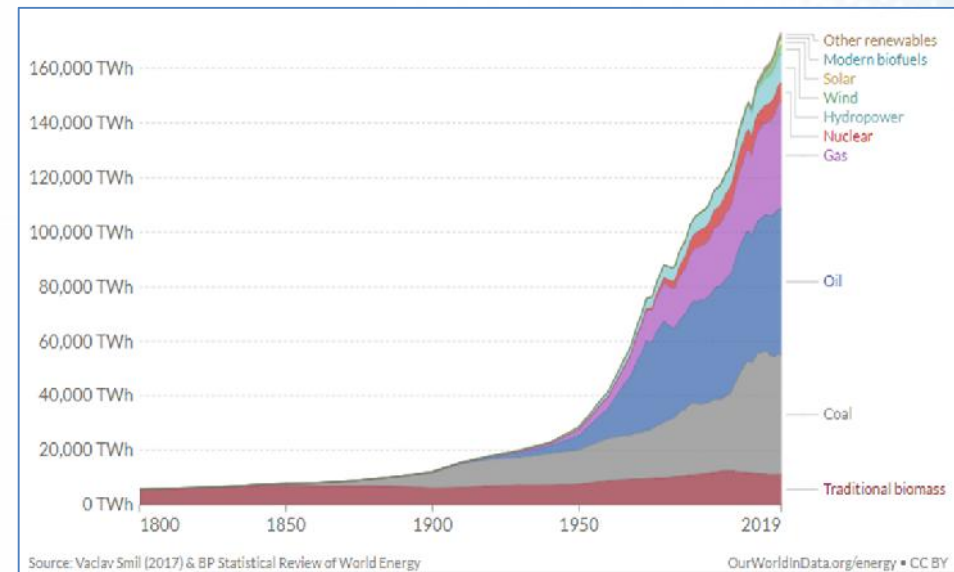
Energy

2019:

100 000 000 oil barrels / day

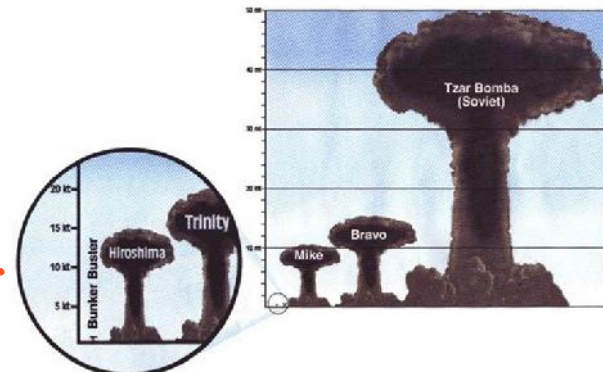
15 898 729 m³/day = 4221 olympic swimming pool

5,84 x 10¹⁴ KJ (1 BEP = 5861520 KJ)



Every day we consume ~2 tsar H-bomba (1954) = ~8000 Hiroshima bombs

Oil only!



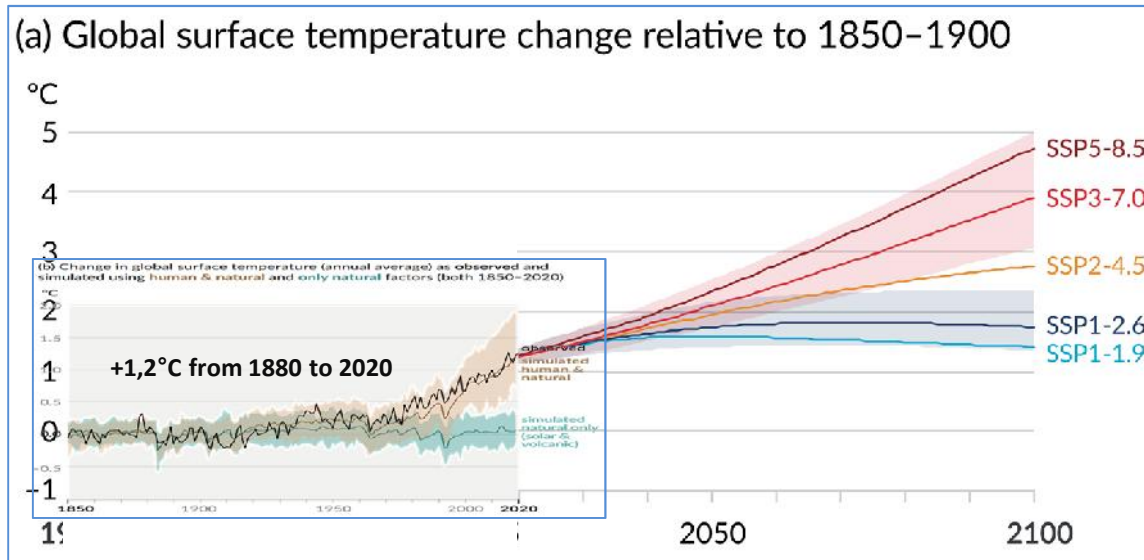
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The bleak prospect

- And things will get worse !

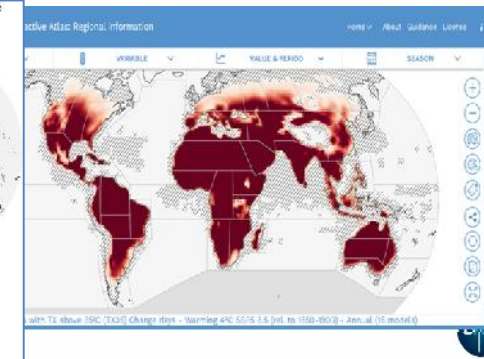
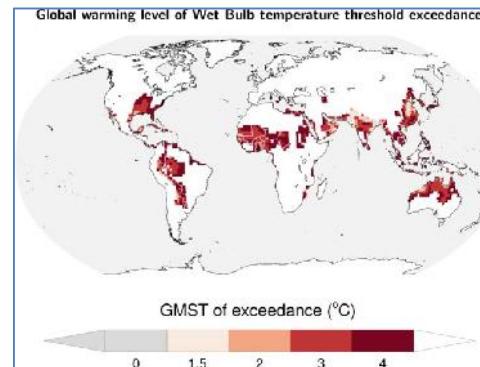


Business-as-usual scenario
(SSP5-8.5 Shared Socioeconomic Pathways 5 with RCP8.5)

© https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf



A barely livable world





My grandmother, 100 yrs old

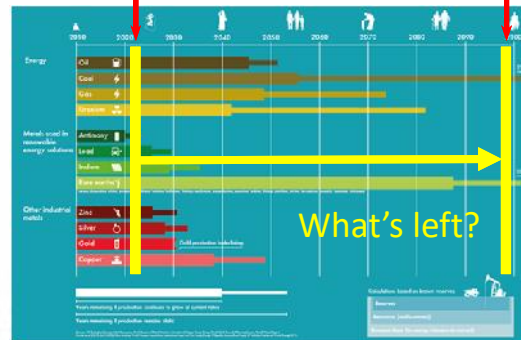


My three daughters, 17, 20, 23

Will my PSE activity enable my children to grow up happily to a 100 yrs ?



today



100 years for my children

→ No in the ~~business~~ science-as-usual scenario

⇒ So, I need to shift my paradigm from cartesianism towards 'La Pensée Complexe'

→ A methodological shift in my science

→ An epistemological shift in my philosophy of science

→ A metaphysical shift in my representation of the world



Preliminary

- **Epistemology**

- The philosophy of knowledge

- The study of how what constitutes valid knowledge (Piaget )

- **Paradigm**

- A distinct set of concepts or thought patterns, including theories, research methods, postulates, and standards for what constitutes legitimate contributions to a field

- Cartesianism (Descartes )

- Rationalism (Leibnitz )

- Positivism (Comte )

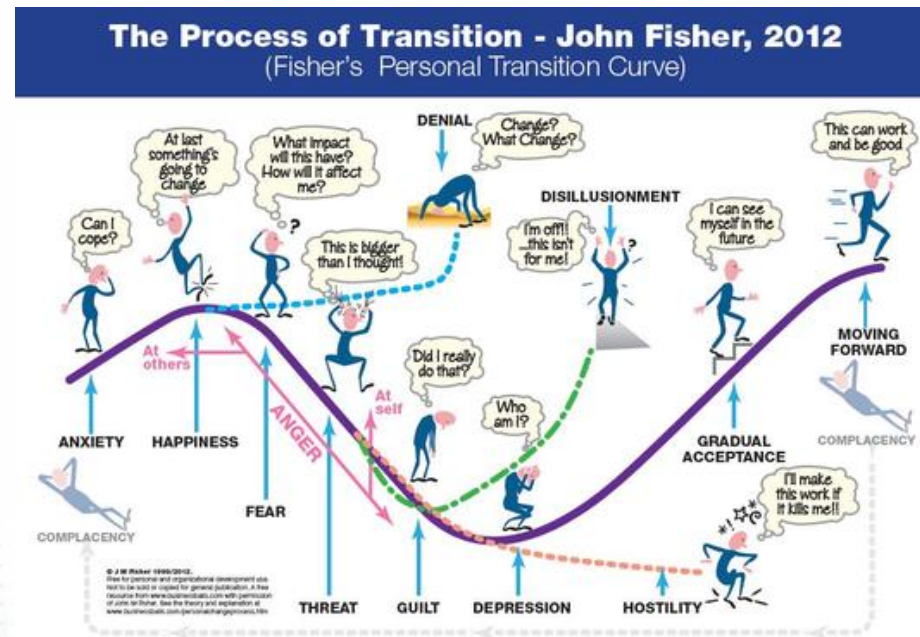
- Constructivism

- educational constructivism.(Piaget )

- pragmatic constructivism (LeMoigne  Avenier  Morin )

Preliminary

- Audience homework 1:
 - Identify the phases of my transition curve



Elisabeth Kübler Ross 1969
John Fisher 2012

- Audience homework 2:
 - build your own transition curve via reflexive thinking!
 - Did you also experience these phases over your career?

Preliminary

- A thermodynamic homology* for my personal transition curve

- Helmholtz « free energy » $F \rightarrow$ Acting capability

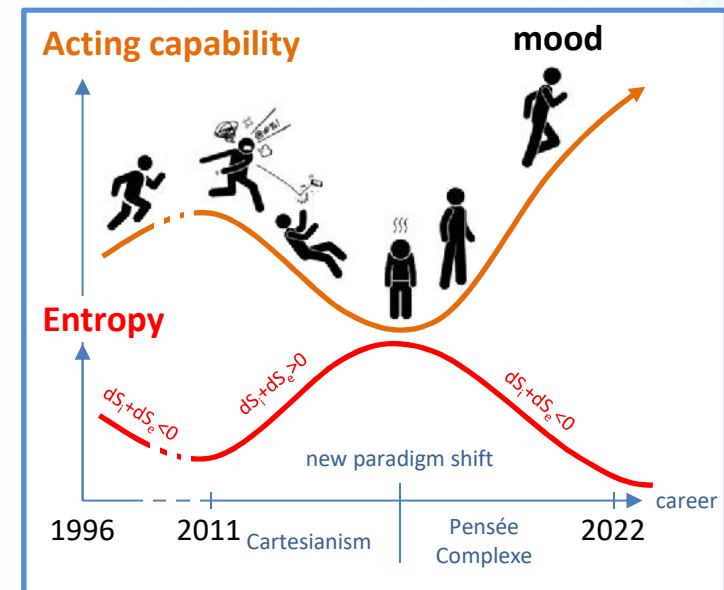
$$dF = dU - T.dS$$

- U / internal energy \rightarrow my resources (knowledge, skills)
- T / temperature \rightarrow physical & cognitive mobility

- S /total entropy for an open system

$$dS = dS_i + dS_e \quad \text{with} \quad dS_i \geq 0 \quad (2^{\text{nd}} \text{ law})$$

- S_i / internal entropy \rightarrow degree of disorganization
 $dS_i \geq 0$ (2nd law) \rightarrow learning needs some effort and dissipates energy
- S_e / exchanged entropy \rightarrow exchanged information (papers, conference, books, thesis)



**Homology: dissimilar reality; similarity at the conceptual level*






Early career 1996 – 2011


The world outside? No need to bother as long as Science goes on.



(Descartes is watching me)

The business-as-usual paradigm

- Cartesianism (Descartes )
 - Rationalism (Leibnitz )
 - Positivism (Comte )
- "Cogito, ergo sum" → reasoning is the source of knowledge
- The world is real and reasoned.
 - Concepts: Faith in disciplinary science approaches, in truth, in logic
 - Principles: objectivity, reductionism, causality, exhaustivity

	Descartes 
<i>In short...</i>	Cogito ergo sum
<i>Approach</i>	causality
<i>Paradigm & Epistemology</i>	rationalism
	materialism
<i>Example</i>	any artefact



Classical PSE: excellency and innovation

• 15 thrilling years of conventionnal PSE/CAPE

– Quest for numbers & excellency

• Running for fundings usually as Principal Investigator

- FR fundings: ANR, ATIP,
- EU fundings: FP6, FP7, H2020
- Local fundings
- Industry-backed fundings

• Industry driven topics

• Rewards

• PhD thesis students

• MSc students,

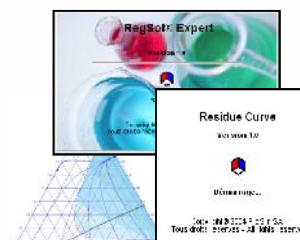
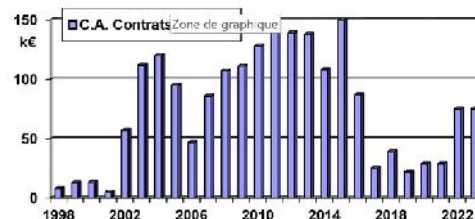
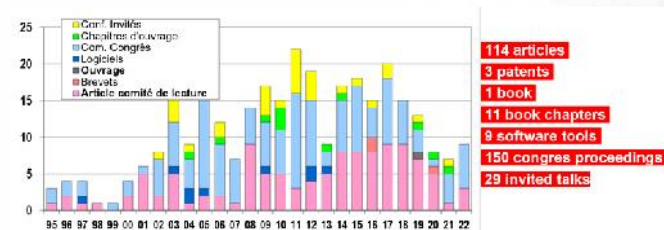
• Publications

• Conferences

• Books

• Patents

• Software tools





Classical PSE: excellency and innovation

- **PSE/CAPE fields and approach**

- **Topics**

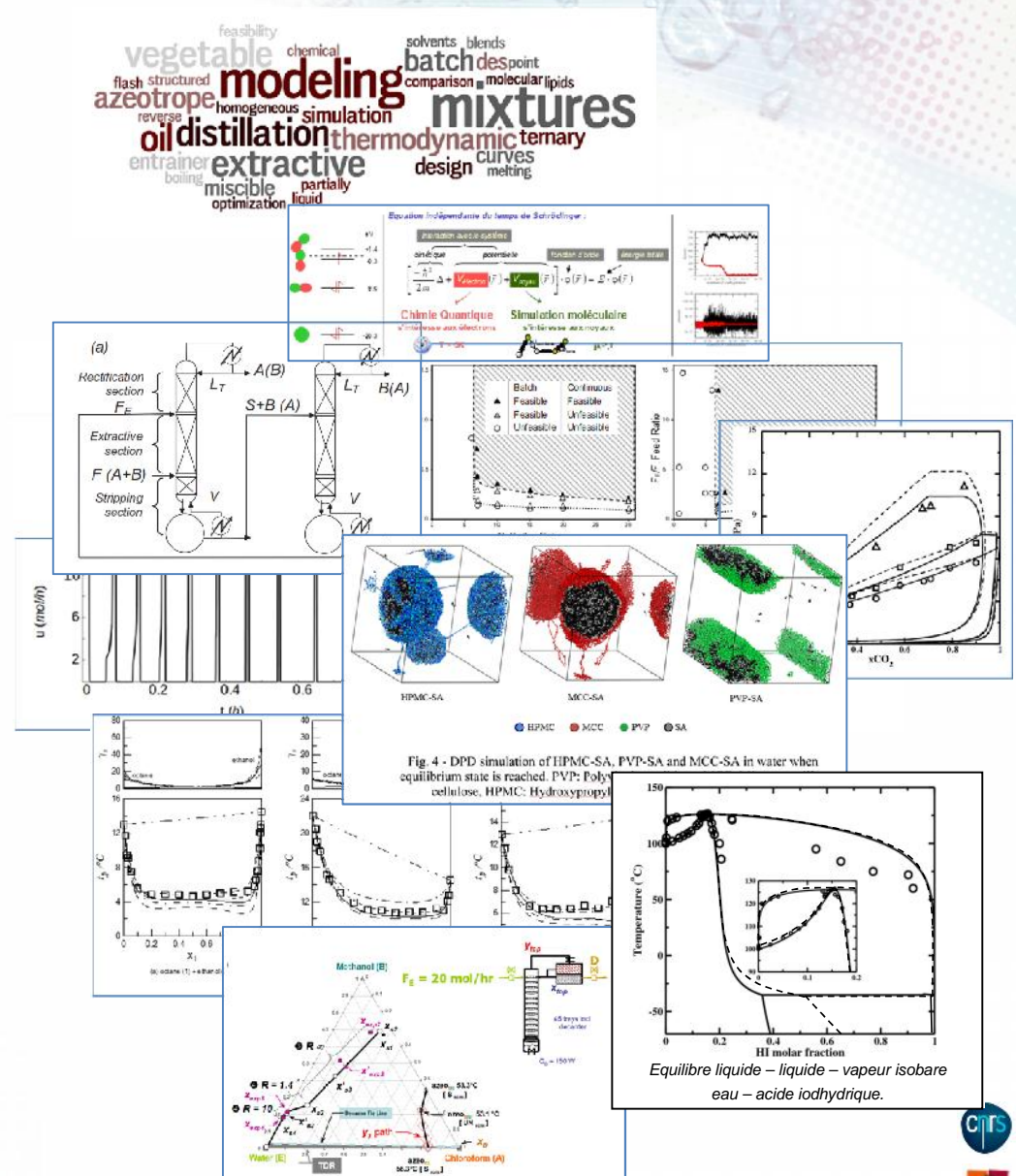
- Tailored computer aided molecular and solvent design
- Extractive and azeotropic distillation
- Hybrid energy production plant
- Thermodynamic modeling

- **Multiscale**

- Molecules → → Aggregates →
→ Fluids → → Unit operation →
→ Plant → → Supply chain

- **Multiple approaches**

- Conceptual design
- Simulation
- Optimization
- Control
- Scheduling





Classical PSE: excellency and innovation

- **PSE/CAPE expertise**

- **Modeling**

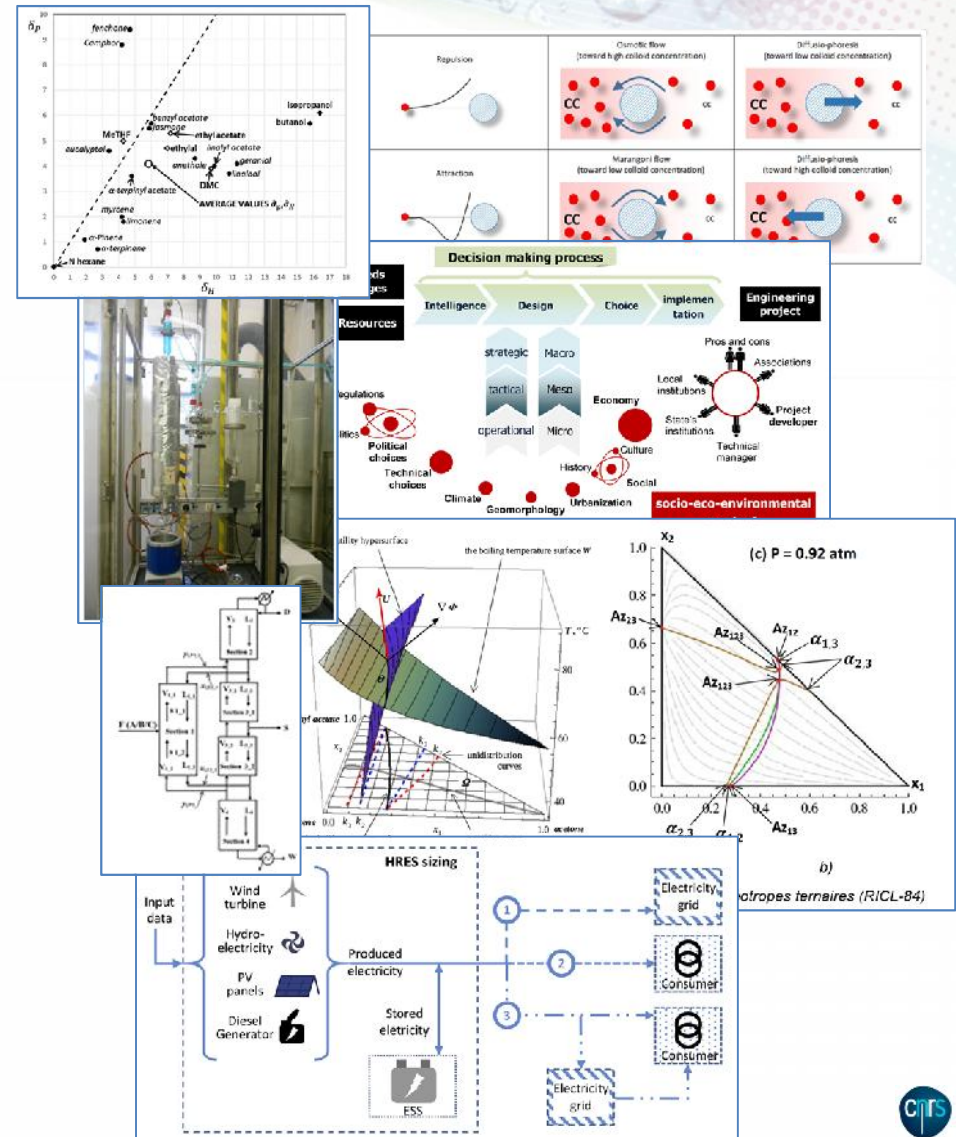
- Local transport phenomena (heat, mass, CFD)
- Global mass & energy balance
- Phenomenological-driven
- Data-driven (NN)

- **Numerical methods**

- Molecular simulation
- PDAE & NLAE; steady state (NR) & dynamic (RK4, Gear); simulation
- Stochastic optimisation (MC, GA)
- Deterministic optim. (NR, LP, MINLP)

- **Thermodynamics**

- SLE, VLE, SLLE, supercritical
- EOS, G^{ex} models
- Molecule and mixture property prediction
 - Group Contribution, QSAR,
- Exergy analysis
- Nonequilibrium thermodynamics



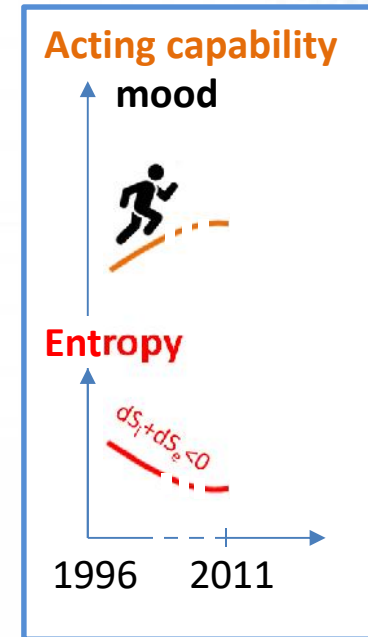


My entropy sensor

- **Acting capability ($dF = dU - T.dS$) is increased**

- As I gain knowledge and expertise, $dU > 0$
- Conferences, reviews, meetings : T is quite high
- Entropy change is globally ($dS = dS_i + dS_e$) < 0
 - I spend energy for learning, so $dS_i > 0$
 - I publish, give talk, supervise students, so $dS_e \ll 0$

$$dF = (dU - T.dS) > 0$$





Classical PSE: excellency and innovation

“purity reached 99.8%”

“design method was validated by batch simulation and experiments”

“the total energy consumption was improved by 23.6%”

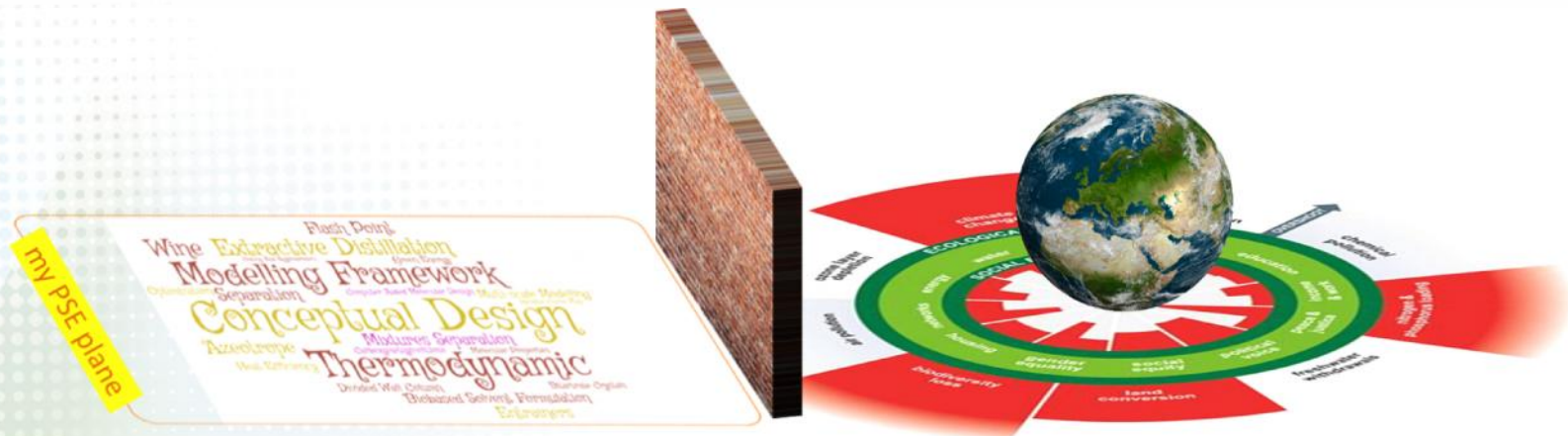
“Computer time was 5.6s for the 2300 variable problem”

“it is the first time a thermodynamic model of two demixing aqueous phases is proposed”

“impurity estimate is 135 ppm, compared to 23 ppm measured”

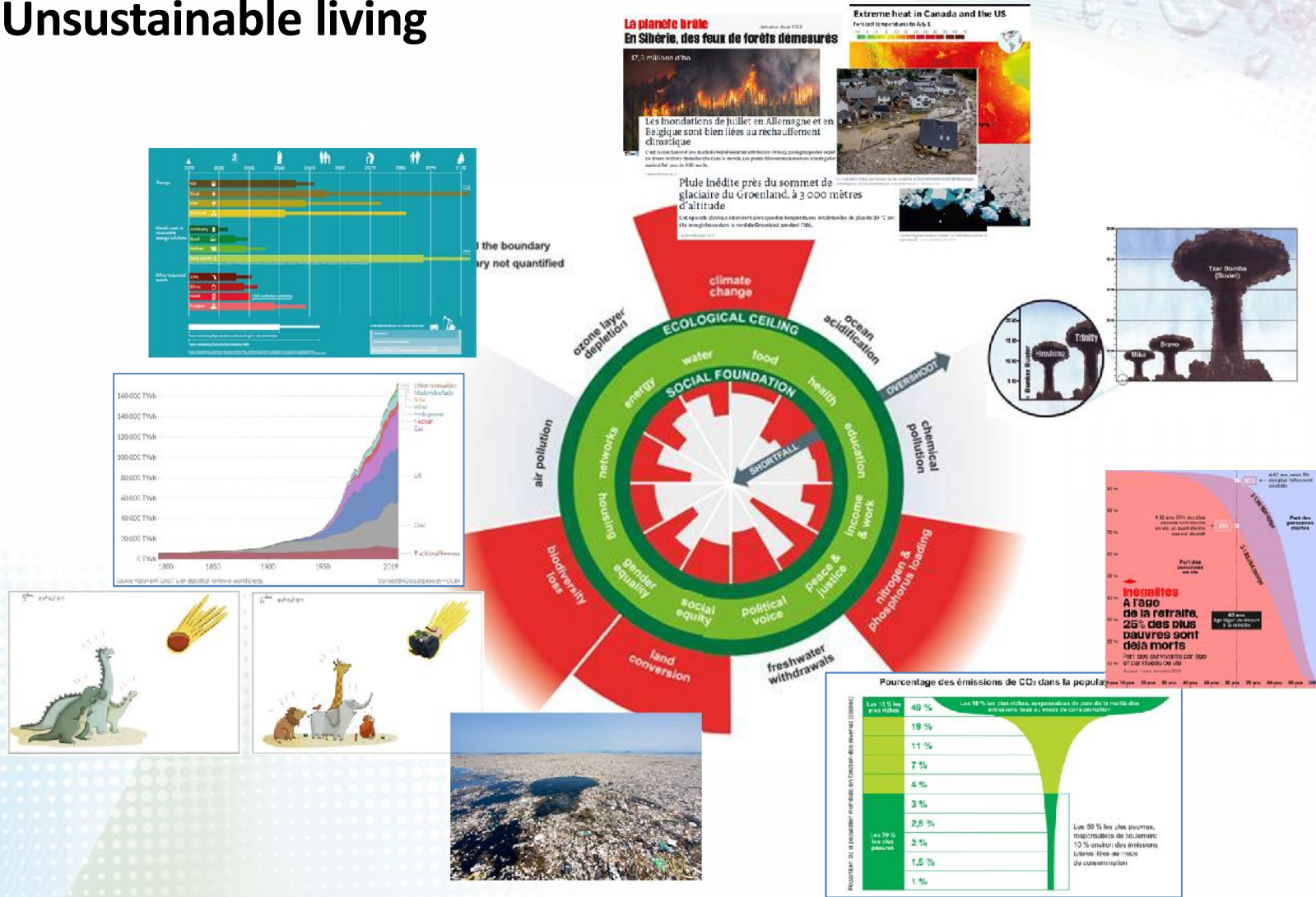
“The solvent property matched the target values within a 5% marging”

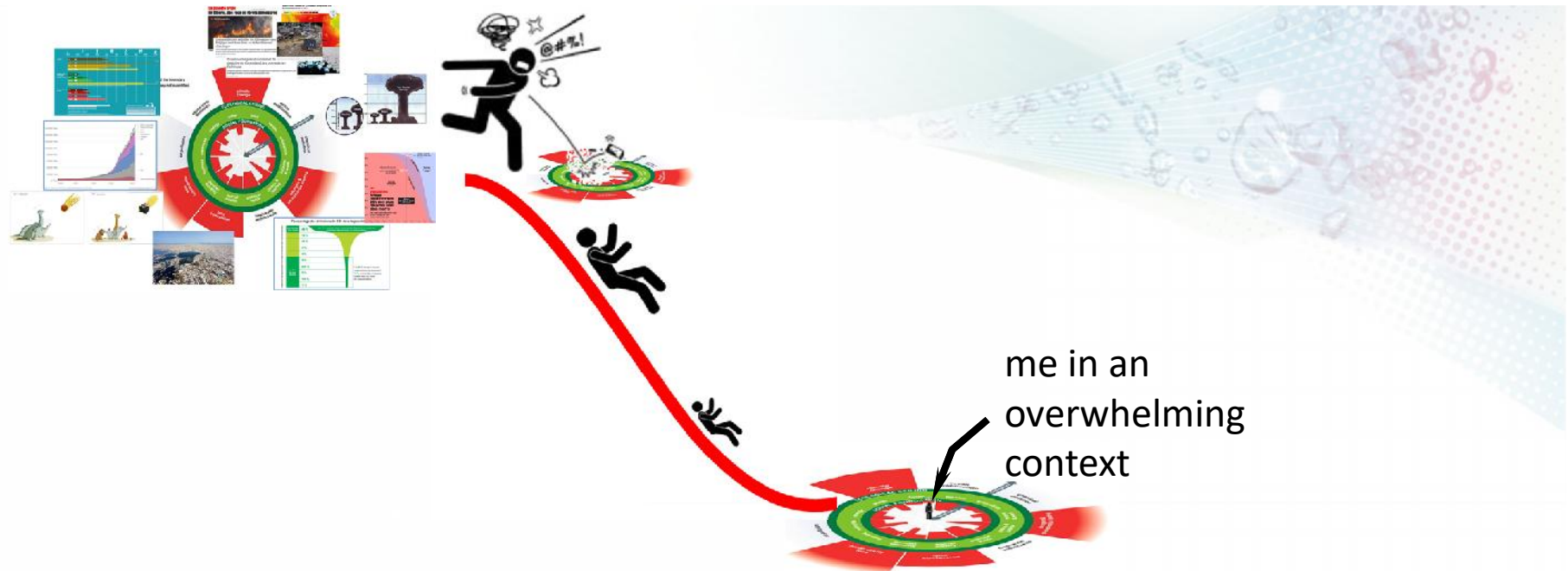
- **But is this meaningful with respect to global changes?**



The bleak prospect is there

- Unsustainable living





The fall... 2011 – 2016

Personal introspection

How am I to cope with the world changing outside?

Professional introspection

Is my PSE work meaningful wrt. the global challenges of our world?



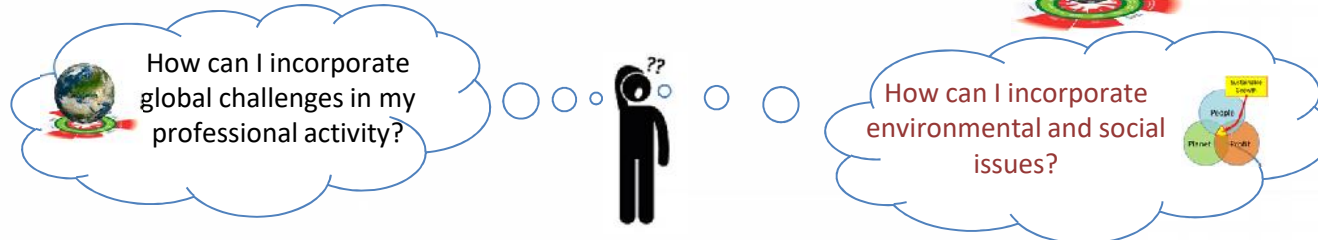
(Descartes is still watching me !)



Should I stick to my paradigm?


- **Come-on man, be rational!**  (Descartes is watching me)

– **Reductionnism:** rephrase the global questioning  into 



- **Come-on man, use a systemic/complex approach!**

– Well, call it « limited complexity »

	Descartes 	
<i>In short...</i>	Cogito ergo sum	limited complexity (complicated)
<i>Approach</i>	causality	dealing with 'the' complexity
<i>Paradigm & Epistemology</i>	rationalism	
	materialism	
<i>Example</i>	<i>any artefact</i>	<i>a plane</i>



Facing the global challenge

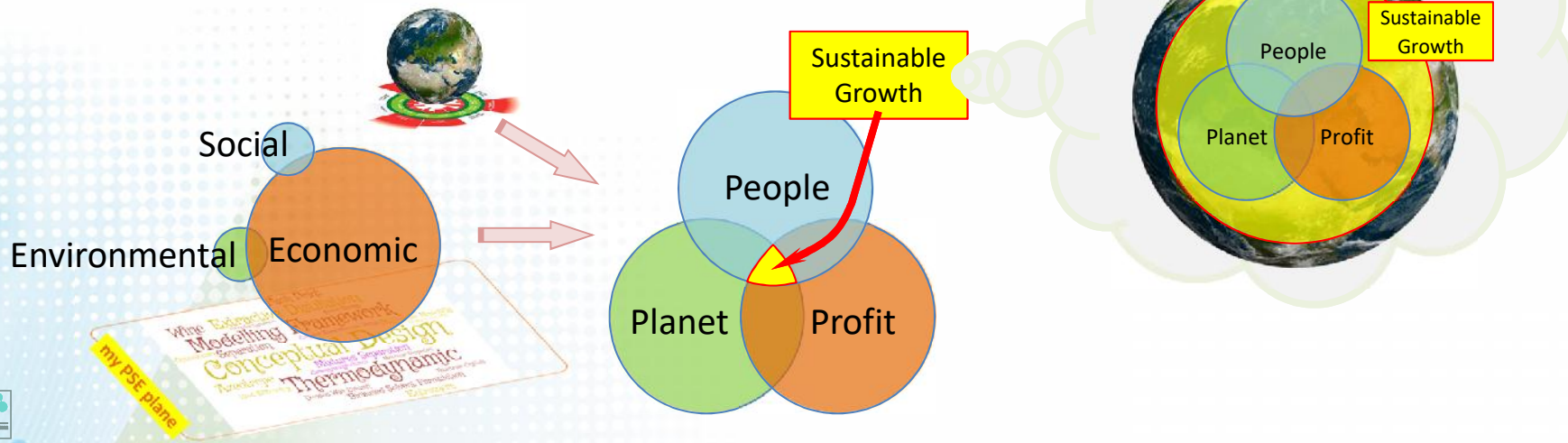


- **Come-on man, be rational!**



(Descartes is watching me)

- Decision: Let's drop the personal introspection and keep the professional one
 - How can I incorporate global challenges in my professional activity?
 - Any problem has a **solution!**
 - I need to set **objectives!**
 - **Solution:** incorporate the three pillars of Sustainable Growth : economic, social, environmental in my activity





Facing the global challenge






- Let's do the best I know in classical PSE:

Thermodynamic 1st
(MESH balances)
and 2nd law



Approach	Technique	Limits
Modeling	Multiscale modeling	Not trivial to connect local simulation into global model
	Simulation	Dynamic better but harder than static
	Multiobjective optimization	
	multiple-criteria decision analysis	Should I weight factors to take a decision?

Criteria	Key Performance Indicators	Limits
 Economics	Cost analysis	
 Environment	Environmental Indicators	Complex & uncertain impact assessment
 Social	Job creation	

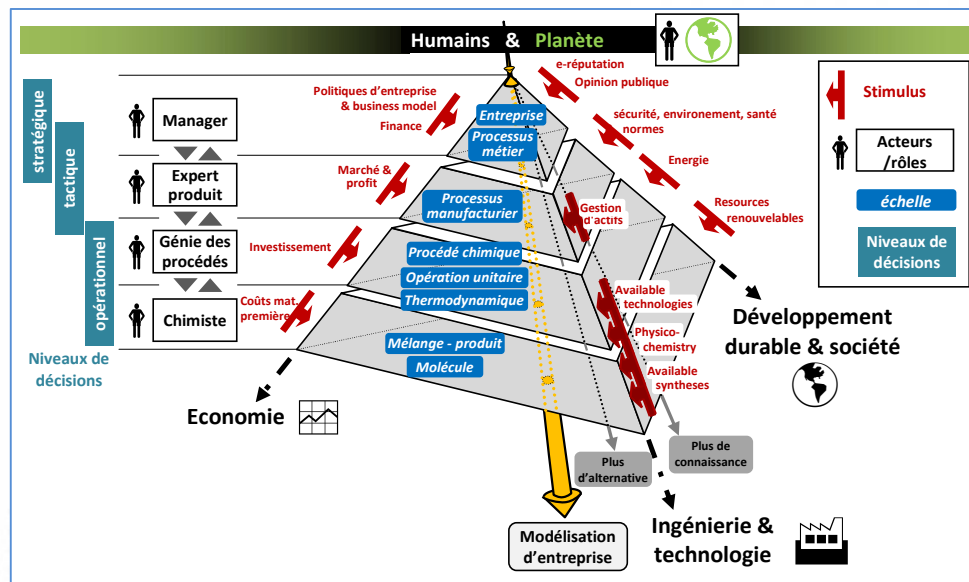
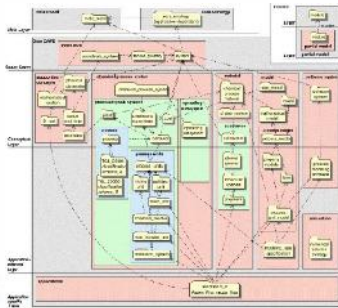


Some examples of a “cartesian complexity”

- **Sust. Growth concern** ● ● ● **at MACRO scale:**
 - A framework of sustainable chemical enterprise model and decision-making process
 - Based on Model driven Engineering & multiscale modeling

J. HEINTZ, J.P. BELAUD D, V. GERBAUD. Chemical enterprise model and decision-making framework for sustainable chemical product design. *Computers in Industry*, 65(3), 505-520, 2014

J. MORBACH, A. YANG, W. MARQUARDT, OntoCAPE—A large-scale ontology for chemical process engineering, *Eng. App. Artif. Intell.* 20(2), 147-161, 2007



- Tentative to develop a framework embedding stakeholders and constraints within a pyramidal and rather rigid chemical enterprise perspective
 - Pro: Explicit stakeholders and constraints
 - Pro: dissociating “financial economy” from “sustainable development and society”
 - Cons: Still a mainstream & rigid vision

Some examples of a “cartesian complexity”

- **Environmental concern** at micro-scale:

- Computer Aided bio-solvent design

- Multiple-criteria decision analysis
- Model driven Engineering

- UML2, BPMN
- SBVR, OCL

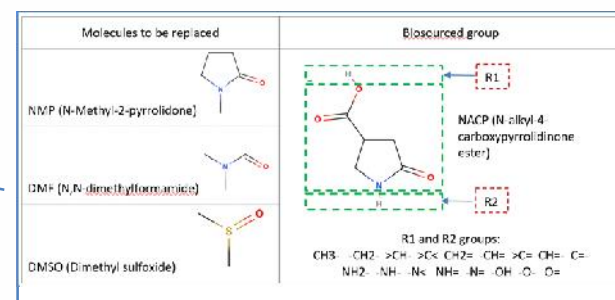
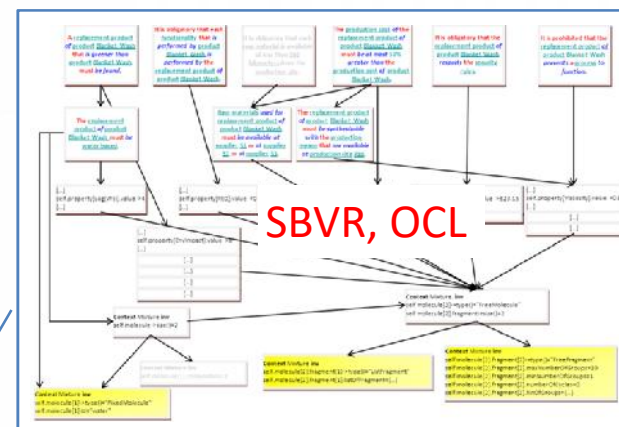
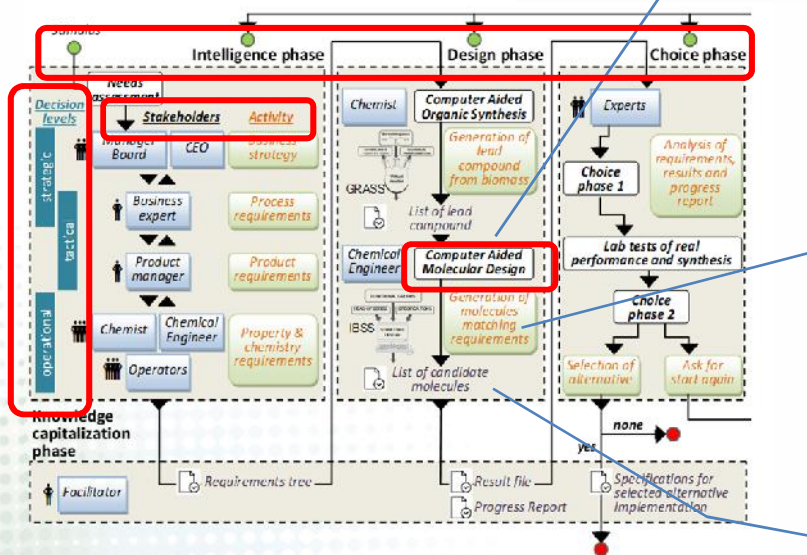
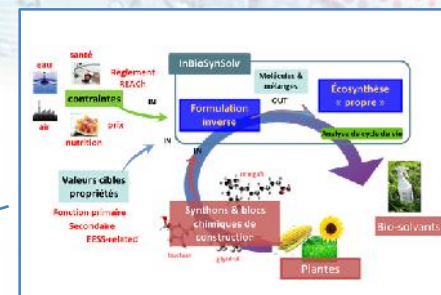


Figure 1. Decision-making process for the design of molecule satisfying desired properties and being synthesizable from biomass

V. GERBAUD, TELES DOS SANTOS M., PANDYA N., AUBRY J.M. Computer aided framework for designing bio-based commodity molecules with enhanced properties. *Chem. Eng. Sci.*, 159, 177-193, 2017

L. MOITY, MOLINIER V., BENZAOUZ A., JOOSSEN B., GERBAUD, V., AUBRY J.M. A “top-down” in silico approach for designing ad hoc bio-based solvents: Application to glycerol-derived solvents of nitrocellulose. *Green Chem.*, 18, 3239-3249, 2016.



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Some examples of a “cartesian complexity”

- **Social & environmental concern** at **MACRO scale**
 - MO MINLP goal programming - MS modeling of a bioethanol supply chain
 - Biomass seasonability, geographical availability, biomass degradation, process conversion technologies, product demand

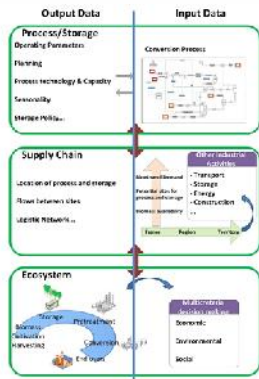


Fig. 1. Illustration of the workflow diagram with multi scale modeling

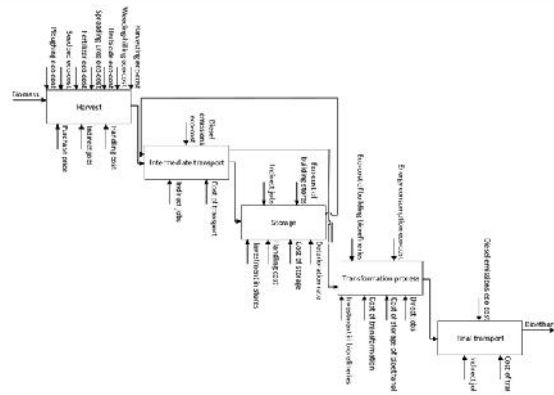


Fig. 2. Superstructure of biomass supply chain model.

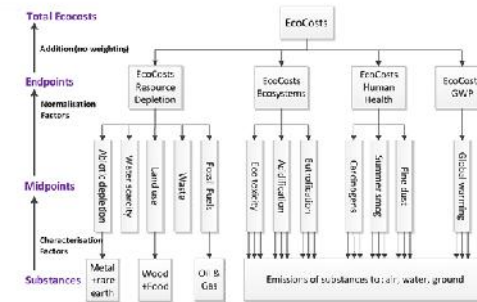


Fig. 3. Structure of the system of ecocosts 2012 (www.ecocostvalue.com).

- Economics: cost
- Environment impact = Eco-cost LCA method
- Social benefit = job creation
 - » *Direct & indirect jobs* | process plant size
 - » *Induced jobs* : based on geographical location

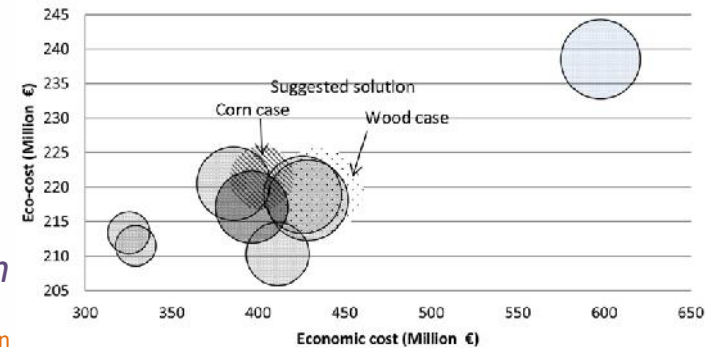


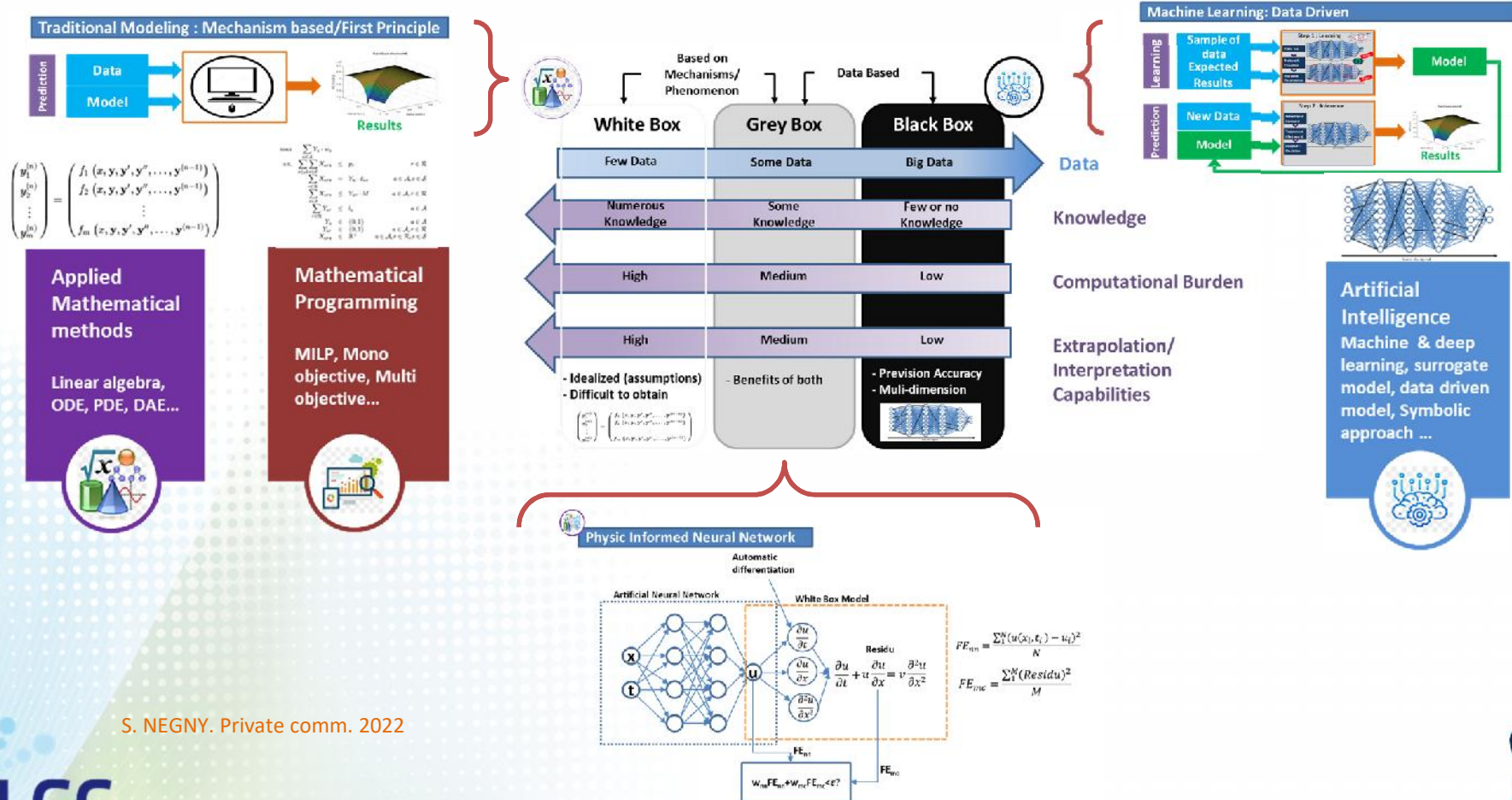
Fig. 8. Comparison between economic cost Ecocosts and jobs creation for wood and corn biorefineries.

C. MIRET, P. CHAZARA, L. MONTASTRUC, S. NEGNY, S. DOMENECH. Design of bioethanol green supply chain: Comparison between first and second generation biomass concerning economic, environmental and social criteria. *Comput. Chem. Engin.*, 85, 16-35, 2016



Some examples of a “cartesian complexity”

- The technosolutionist illusion “A.I will take care of all”
 - Combining data driven & process engineering physics models for new modeling approaches
 - “grey box” Hybrid approach



S. NEGNY. Private comm. 2022





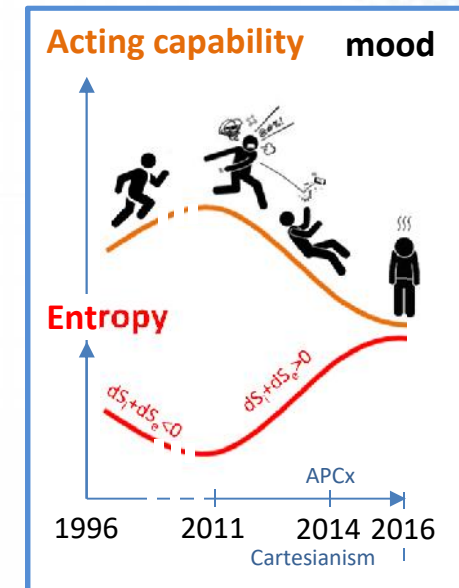
My entropy sensor

- **Acting capability is decreasing**

- I still gain knowledge and expertise, $dU > 0$
- T remains high as I delve deeper into PSE/CAPE
- Entropy change is globally ($dS = dS_i + dS_e$) $\gg 0$

I'm in a state of cognitive dissonance!

- My energy is dissipating into states inaccessible for action
→ entropy is growing
 - I still spend energy for learning, so $dS_i > 0$
 - $dS_e \sim 0$ since I struggle to organize my thinking and to devise some professional action compatible with sustainable growth and hopefully global issues.



$$\text{So, } dF = (dU - T \cdot dS) < 0$$





Facing the global challenge



- Cartesianism → cartesian systemic complexity :

I do the best I know, but is that enough?

Descartes is watching me



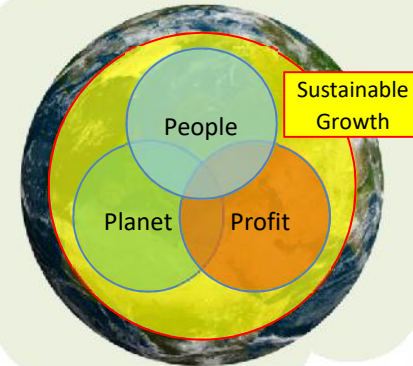
Methodology

Can everything be assigned a cost?

Can human be modelled so approximately?

Epistemology

Is that enough to match my concern?



Metaphysics



Thermodynamic 1st (MESH balances) and 2nd law



Cartesianism + Cartesian complexity



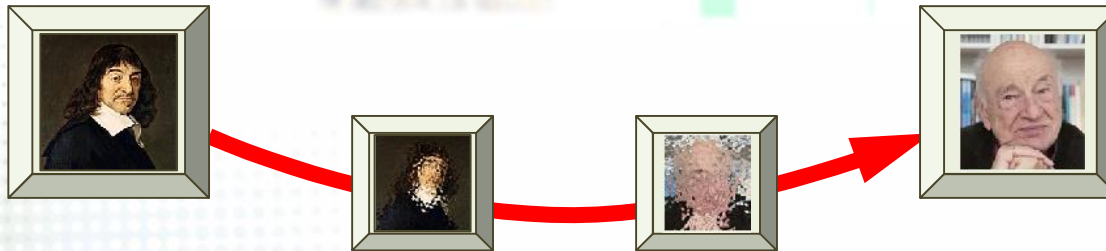
→ No

⇒ So, I need to shift my paradigm





depressing situation; much like in jail
 → I need to shake the bars of the cage







Shattering & shifting the frame




Bifurcating from cartesianism to 'La Pensée Complexe'



Bifurcation starts with an insignificant event

- **April 2014: workshop “Acting-Thinking in Complexity”**
 - Important notice: ‘*in*’ complexity rather than ‘*the*’ Complexity

	Descartes 		Morin 	LeMoigne  Avenier 
<i>In short...</i>	Cogito ergo sum	limited complexity (<i>complicated</i>)	general complexity	subjective complexity
<i>Approach</i>	causality	Thinking ‘ <u>the</u> ’ complexity	Thinking ‘ <u>in</u> ’ complexity	Acting-Thinking ‘in’ complexity
<i>Paradigm & Epistemology</i>	rationalism		constructivism	
	materialism	materialism	materialism	subjectivism
<i>Example</i>	any artefact	a plane	the mobility issue	Should I move?

- Constructivism:
 - Knowledge of reality is a human construct using science but also experience, intuition
 - » *La "pensée complexe" (Morin ) "Agir-Penser en complexité" (LeMoigne  Avenier *
 - Interdisciplinarity, subjectivity, path dependency, partiality and uncertainty
 - Principles: interrelation, irreductionism, hologrammatism, recursivity, bifurcation, non-linearity, emergence, dialogic, ecology of action, self-organisation, autocriticism, no forecasting...
 - » *Other similar approach:*
 - The “School of Palo Alto” on systemic and relational approach



Rising at last! the paradigm shift

Confidence in the future

Acting – thinking in complexity



Morin



LeMoigne



Avenier





Three necessary shifts

1. A metaphysical shift

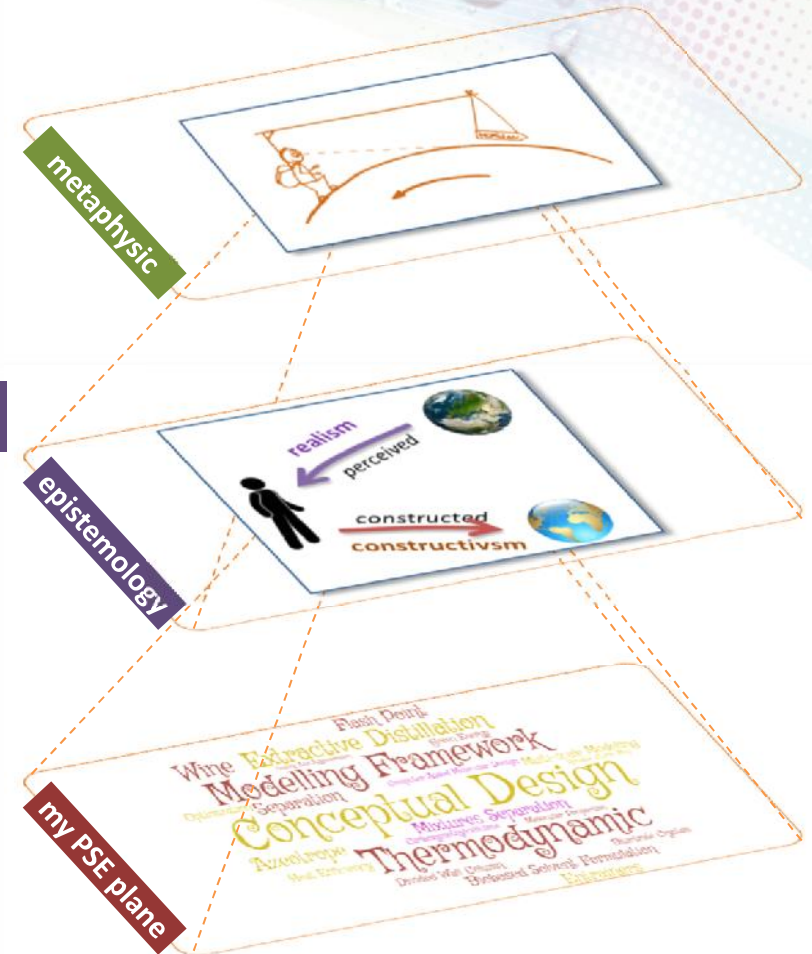
Metaphysics

- Like every living creature, I walk in a changing world along a path towards the ever farer horizon

2. An epistemological shift

Epistemology

- Pragmatic constructivism of LeMoigne & Avenier
 - Concepts:
 - Interdisciplinarity, subjectivity, path dependency, partiality, uncertainty, experiential learning
 - Principles of La Pensée Complexe:
 - interrelation, irreductionism, hologrammatism, recursivity, bifurcation, non-linearity, emergence, dialogic, ecology of action, self-organisation, autocriticism, no forecasting...



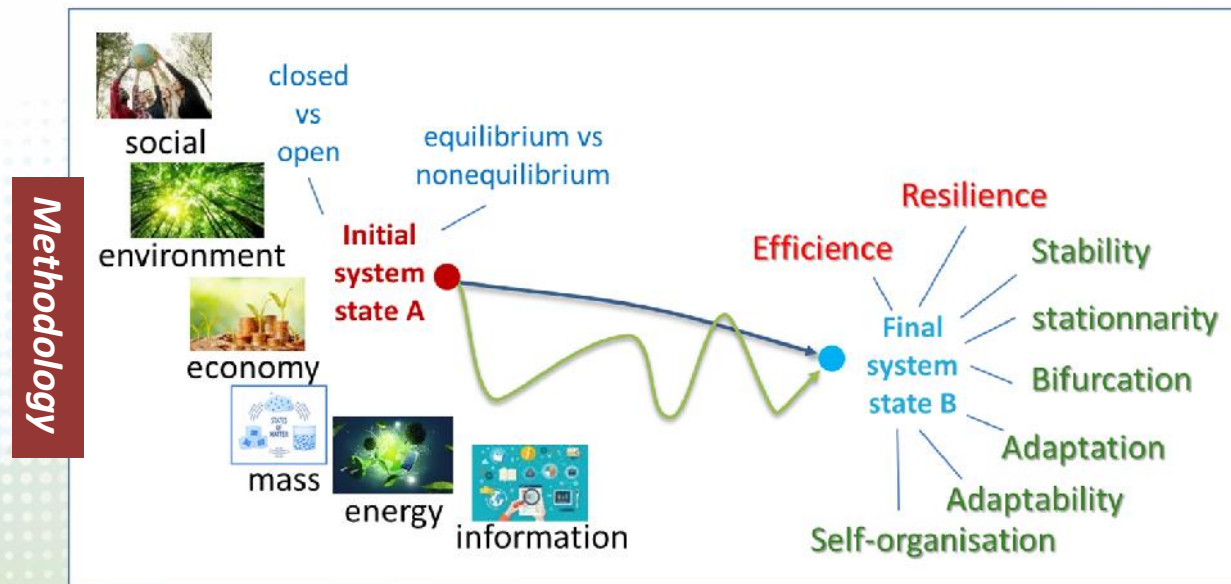
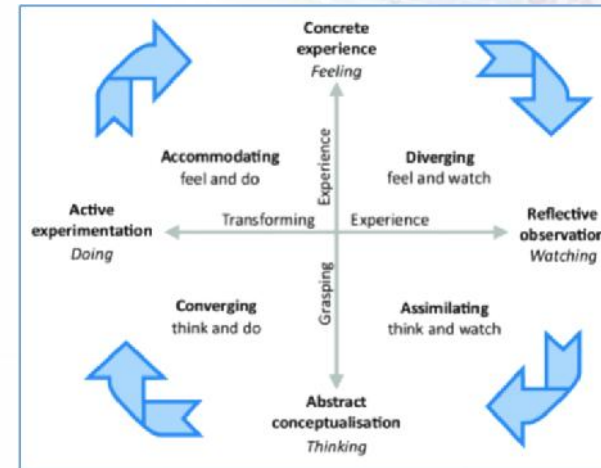


Three necessary shifts

3. A methodological shift Methodology

- Experiential learning whenever possible and a new research focus
- Study socio-ecological transitions
 - Setting a dynamic perspective on complex ecosystems evolution

D.A. KOLB, R. Fry. Toward an applied theory of experiential learning. In C. Cooper (Ed.), Studies of group process (pp. 33–57). New York: Wiley, 1975





practicing *in* complexity: making *connections*

- Exploring non-financial economic theories

– micro

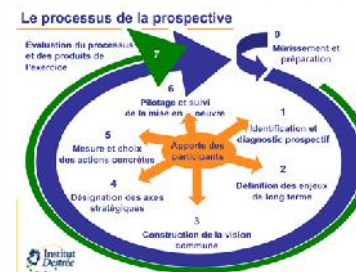
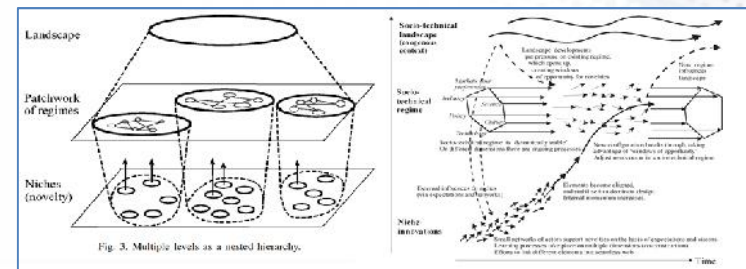
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– Meso

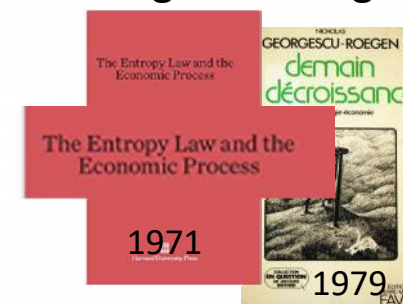
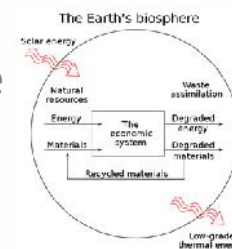
- Geels' MLP: A multilevel perspective on transition pathways in sociotechnical regimes.

– MACRO

- N. Georgescu Roegen: "The entropy law and the economic process" / "tomorrow, degrowth"



Nicholas Georgescu-Roegen

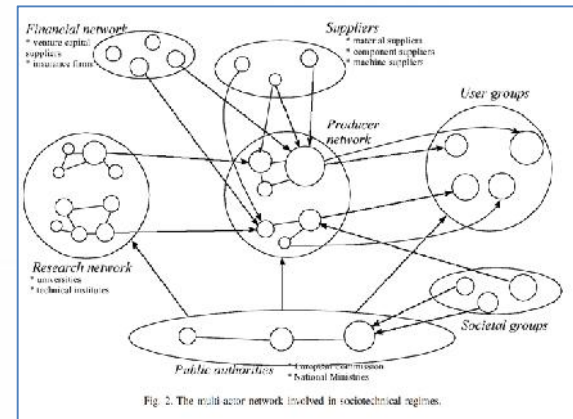




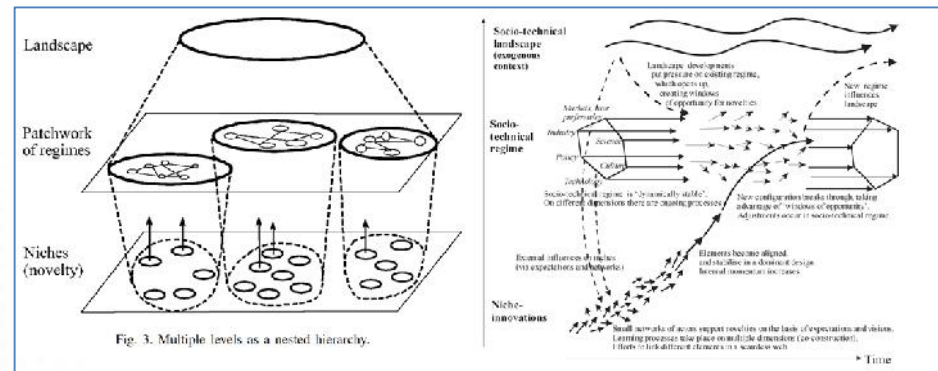
(non financial) economical theories

- **Meso scale: Geels' multilevel perspective on transition pathways in sociotechnical regimes.**

- Multi-actor networks
- Multi-level perspective
 - Niche → where innovation starts
 - Regime → where activity is operant
 - Landscape → surrounding context



- 5 transition pathways
 - Transformation
 - Reconfiguration
 - Technological substitution
 - De-alignment
 - Re-alignment



F.W. GEELS, J. SCHOT Typology of sociotechnical transition pathways. *Res. Policy*, 36, 2007
 F.W. GEELS, Causality and explanation in socio-technical transitions research: Mobilising epistemological insights from the wider social sciences. *Res. Policy*, 51, 2022



(non financial) economical theories

- **MACRO scale: Nicholas Georgescu-Roegen**

- 1971: The entropy law and the economic process

- In french: Demain la décroissance = "tomorrow, de-growth«

- His theoretical claims:

- Physical limits on earth resources impact the economic process
- Any economic process is an open system as in irreversible thermodynamics
- According Thermodynamics' second law , sustainable economic process means that degrowth is desirable

- A leading contributor of bioeconomics

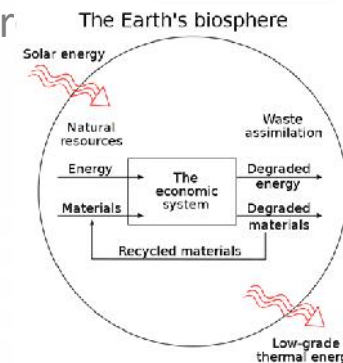
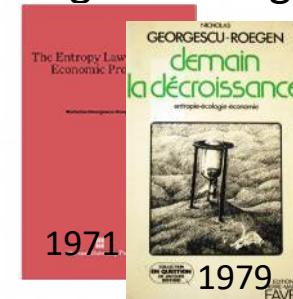
- based on describing economic activity via 'flow-fund' (+stock) appr
 - quite analog to mass and energy balances !

$$[Q(t); R(t); I(t); M(t); W(t); L(t); K(t); H(t)]_0^T \quad (2)$$

avec, pour les fonds, L : la terre; K : le capital; H : les hommes et, pour les flux, Q : la quantité de produit; R : ressources naturelles; I : inputs intermédiaires; M : maintenance du capital; W : les déchets.



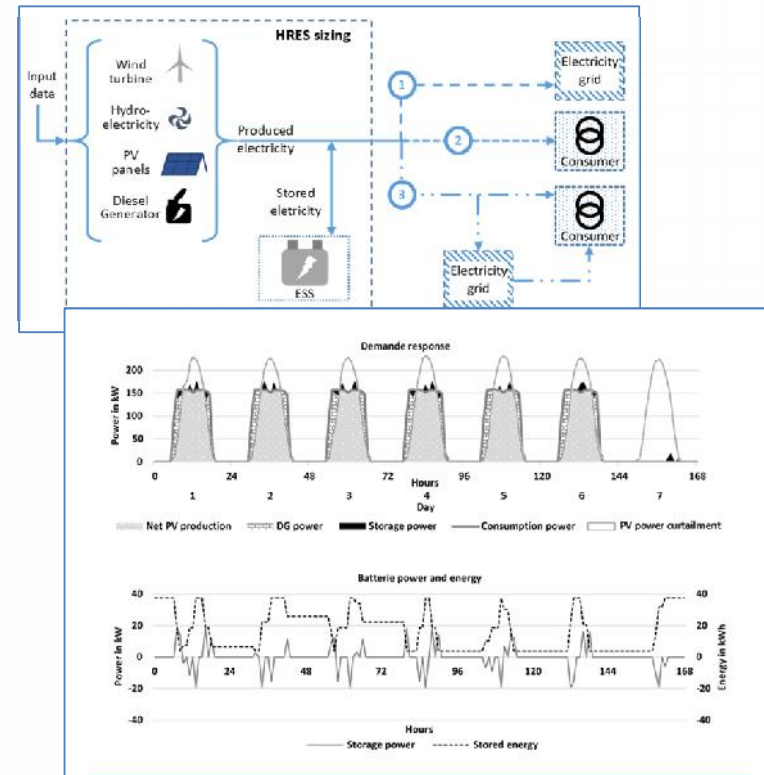
Nicholas Georgescu-Roegen





(non financial) economical theories

- **MACRO scale: Prospective scenarios**
 - Macro-economy prospective simulation
 - (sequel from fund – flow modeling)
 - The 1985' ATHEMA model for the prospective analysis of territorial economy by Ph. Courrage
 - » *Physical economy model based on fund – flow description at the local scale*
 - » *activity described following the NAF and NACE economy activity classification*
 - » *A LP framework solved with GAMS over a 20 year time horizon scenarios*
 - Design of Hybrid renewable energy systems
 - MILP framework solved with ILog



A. ROTH, M. BOIX, L. MONTASTRUC, P. ETUR, V. GERBAUD. A flexible software for optimal design of Hybrid Renewable Energy Systems (HRES) – Case study of a stand-alone HRES for a factory in tropical area. J. Cleaner Prod., 223, 214-225, 2019



practicing *in complexity*: making *connections*

• Exploring social theories of change

– Micro

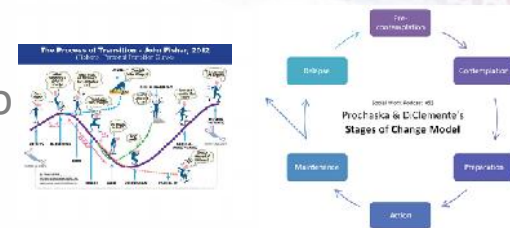
- Individual behavior is what matters and they aggregate to make society

– Meso

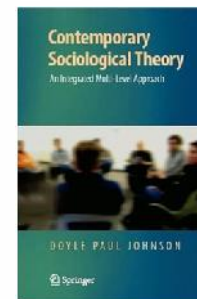
- Clustering mechanism:
 - Groups express values and devise rules in which individual trajectory evolve
 - » *Cursus, social class, ...*
- Lockdown mechanism :
 - Cluster interacts, power relations, self organized system
- Inertia mechanism :
 - Path dependency; regulations and norms; technology, infrastructure

– MACRO

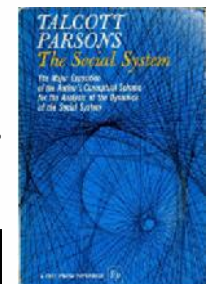
- Society / large number scale behavior
 - Social entropy theories of disorder



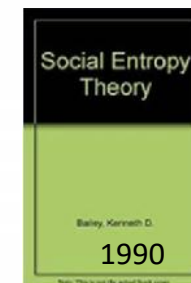
Doyle Paul Johnson



Talcott Parsons



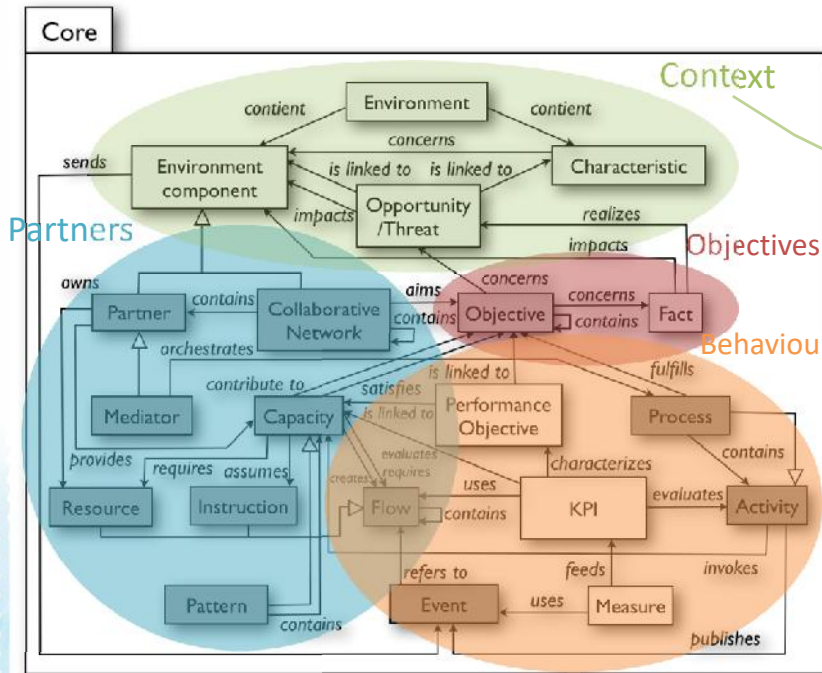
Kenneth D. Bailey





Some examples for tackling social issue

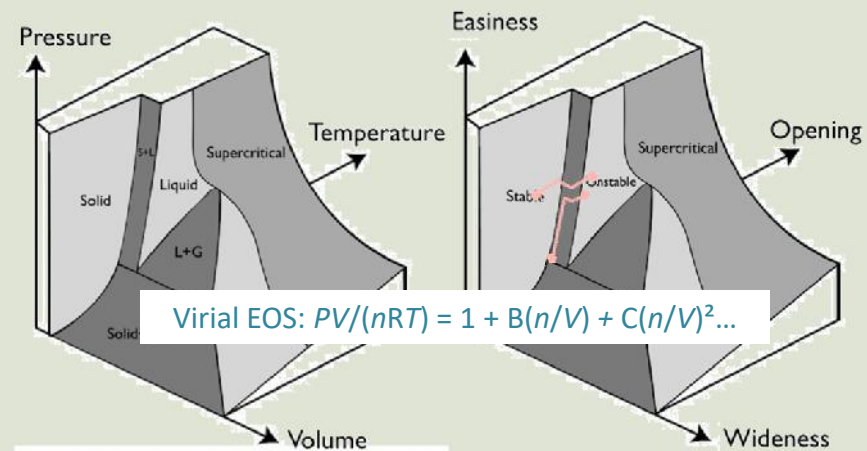
- **MACRO scale: Establishment of collaborative networks**
 - how to increase acting capability?
 - A model-driven engineering approach combined with thermodynamic analogy



acting capability $\Delta F = \Delta U - T \Delta S$

Context is described by state variables

- *opening* (Temperature) presence of competitors, partners, clients and informational / physical connections, [ability to a move]
- *easiness* (Pressure) legal, cultural and financial frame [constraint to a move]
- *wideness* (Volume) market size. [size]



Virial EOS: $PV/(nRT) = 1 + B(n/V) + C(n/V)^2 \dots$

Goal: to go to liquid state where 'stakeholders are neither frozen (solid) nor in chaos (gas); to gain acting capability

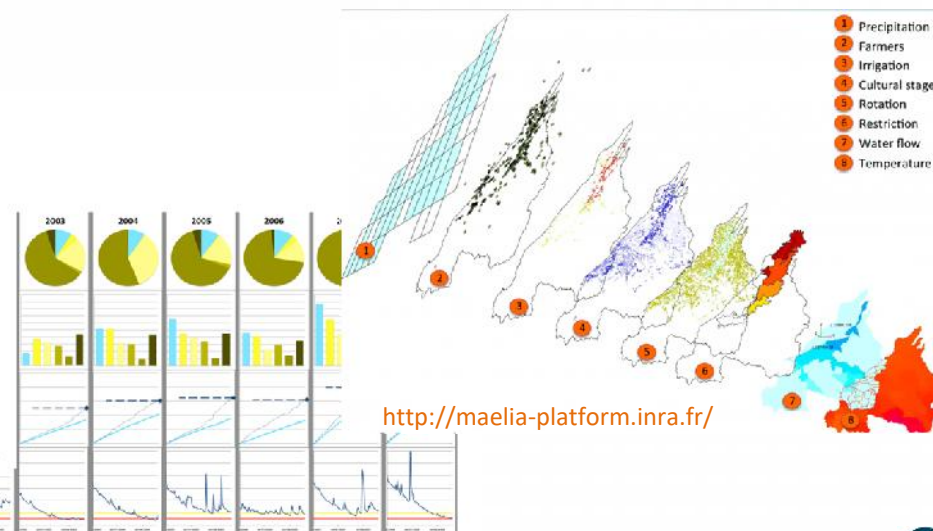
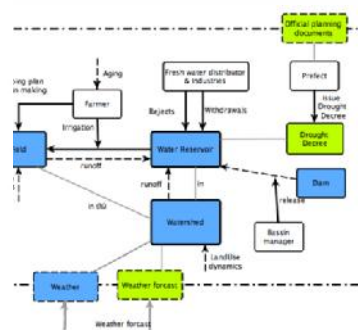
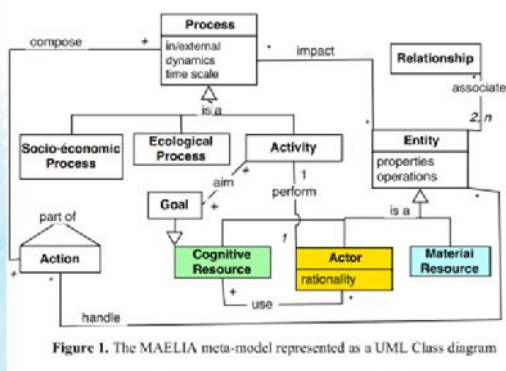
F. BENABEN, V. GERBAUD, A-M. BARTHE-DELANOE, A. ROTH Establishment of collaborative networks – a model-driven engineering approach based on thermodynamics . PRO-VE 2017 Conference





Some examples for tackling social issue

- **Meso scale: The Maelia® Integrated Assessment and Modelling platform**
 - Modelling the social-ecological systems at the farmer scale.
 - A multi-agent platform
 - For assessing the environmental, economic and social impacts of agricultural activities, transformation and recycling of biomass, natural resource management strategies (e.g. water) and global (demography, dynamics of land cover and climate) changes.



B. Gaudou et al. The MAELIA multi-agent platform for integrated assessment of low-water management issues, 2013

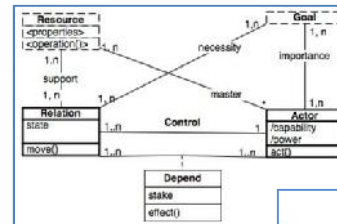




Some examples for tackling social issue

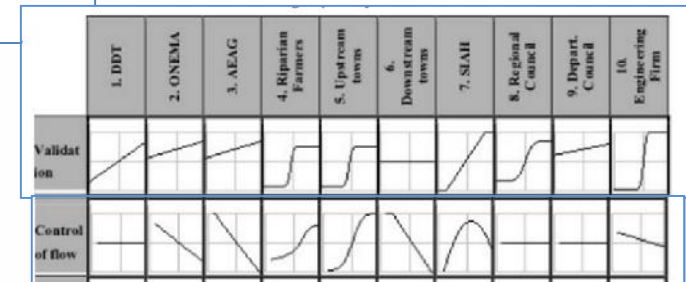
- **micro scale: Soclab: a framework simulating power games in social organizations**
 - based on Le Crozier & Friedberg's sociology of organized action / theory of actor-network
 - Postulate: organizational phenomena are constructed by individual activities and behavior

- A Model-driven engineering approach

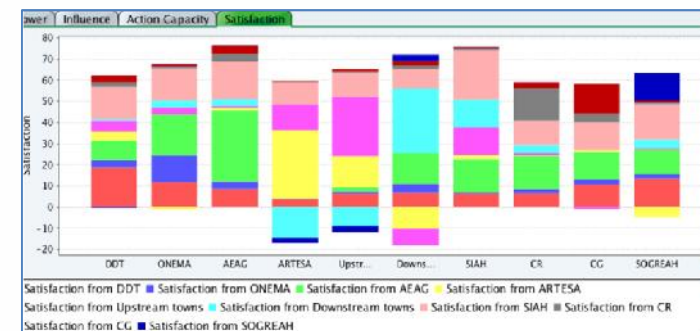


C. SIBERTIN-BLANC, P. ROGGERO, F. ADREIT, B. BALDET, P. CHAPRON, J. EL-GEMAYEL, M. MAILLIARD, S.A. SANDRI SocLab: A Framework for the Modeling, Simulation and Analysis of Power in Social Organizations. J. Artif. Soc. Soc. Simul., 16. 2013

- Modeling of “how stakeholder’s capability is impacted by the +/- variation of each factor”
 - e.g. increase river flow by opening dam lock makes farmers happy



- Multiagent modeling for playing the social game of power relationships
 - e.g. managing river resource
 - » *What is the best compromise (overall capability)*
 - » *Which actors win? Loose?*
 - » *What is the acting capability of each actor?*





My grandmother, 100 yrs old



Conclusion: The new HORIZON – ~~EUROPE~~ Earth



Earth

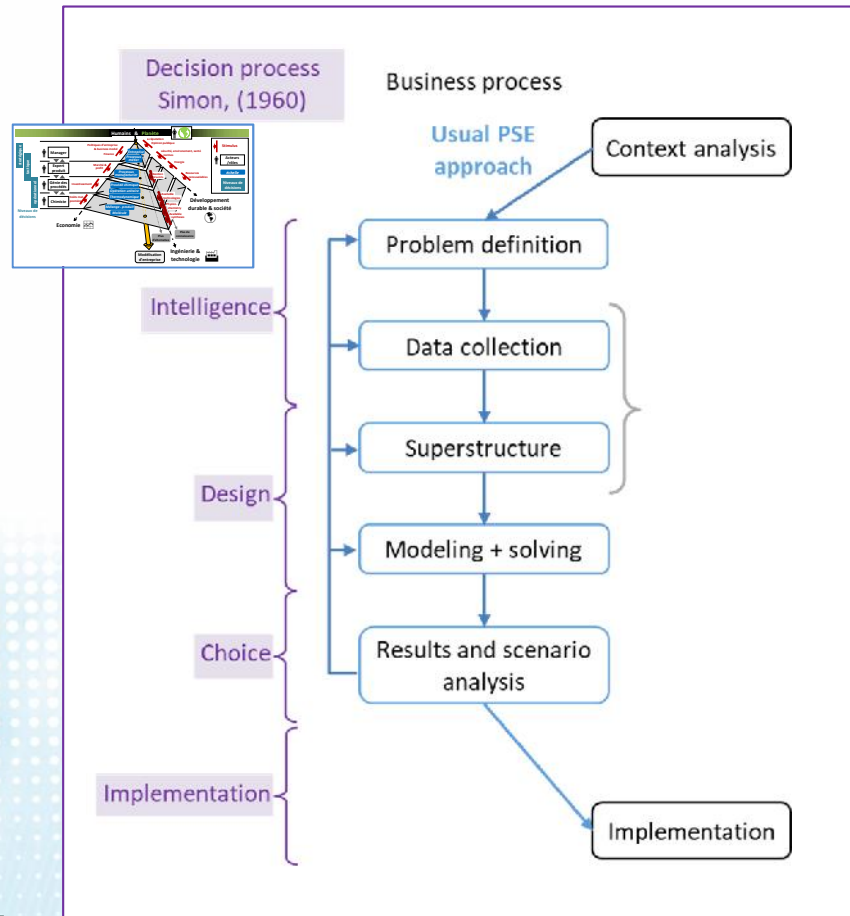
~~EUROPE~~





Some examples on the horizon

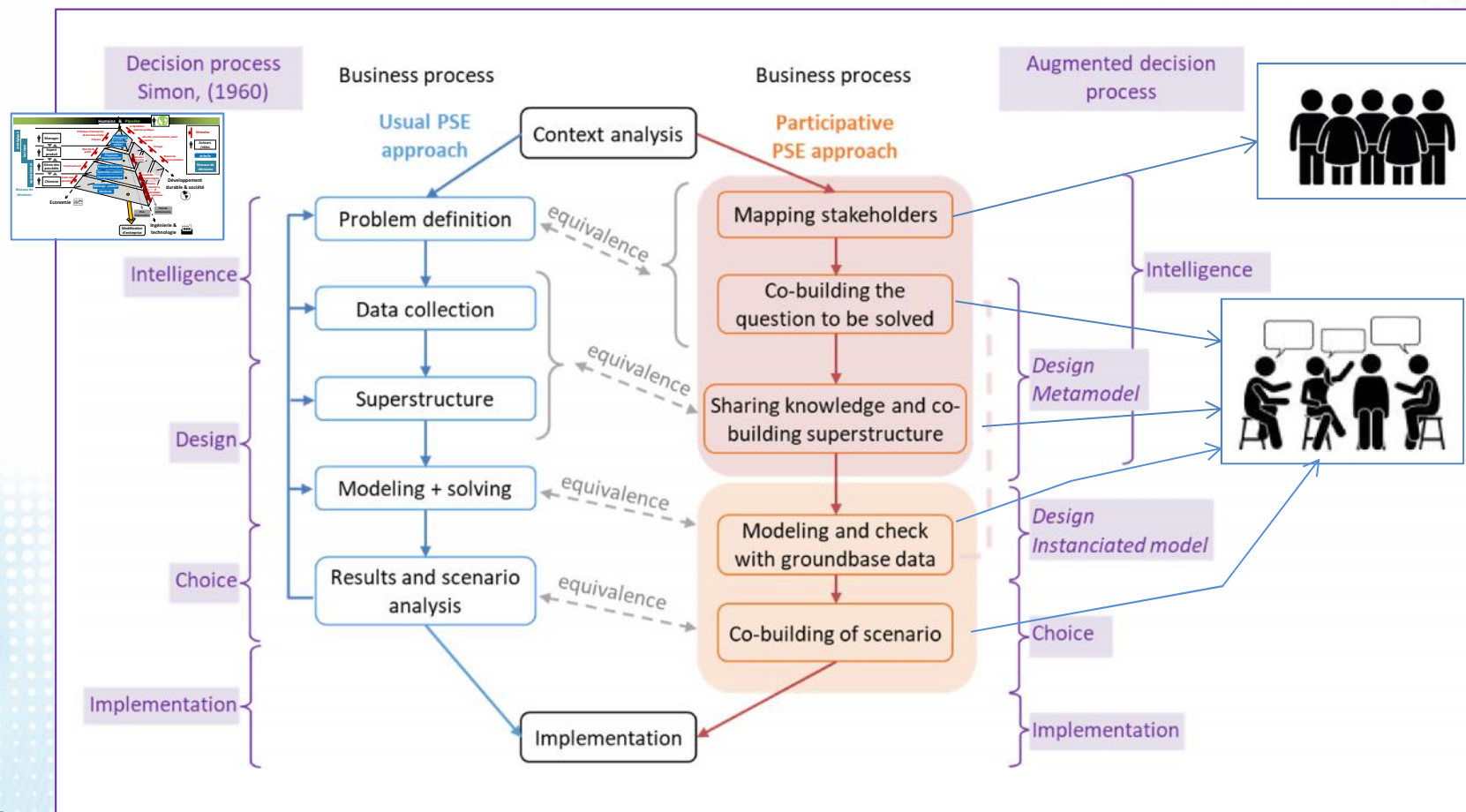
- From a business-as-usual approach





Some examples on the horizon

- Towards a participative co-building and evaluation



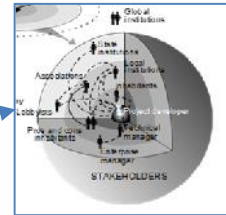
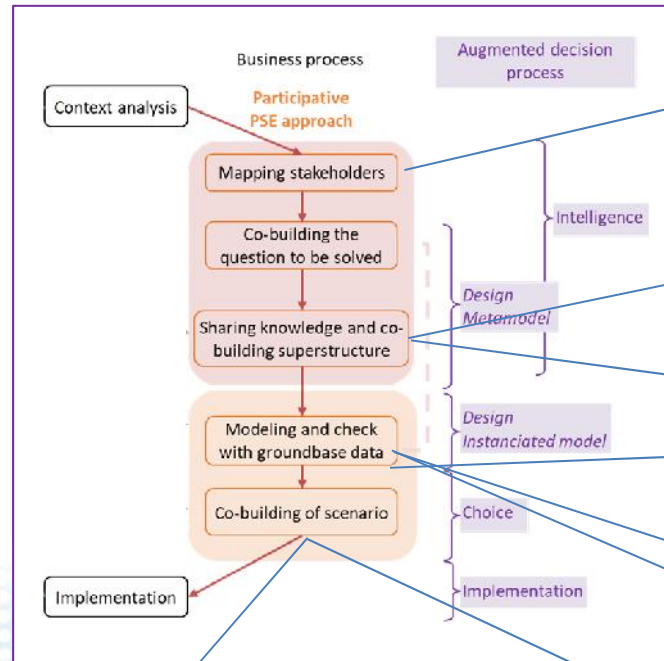
A. ROTH, participative decision process. 2020



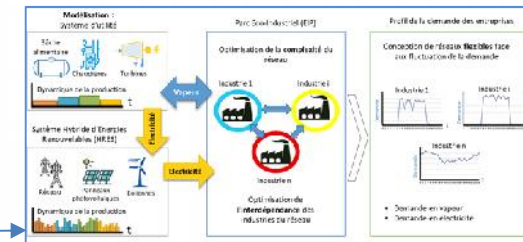
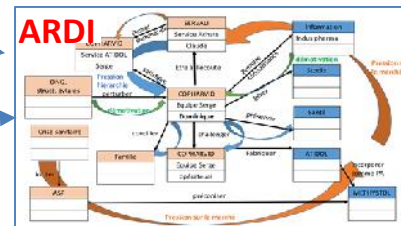
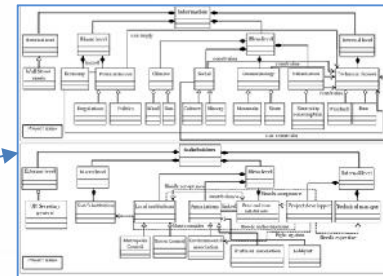


Some examples on the horizon

- Towards a participative co-building and evaluation**



A. ROTH, M. BOIX, L. MONTASTRUC, V. GERBAUD. Holistic framework for land settlement development project sustainability assessment: comparison of El Hierro Island hydro wind project and Sivens dam project. *Comput. Chem. Eng.*, 100, 156, 2017.



MOUSQUÉ, F., BOIX, M., MONTASTRUC, L., DOMENECH, S., NEGNY, S., Optimal Design of Eco-Industrial Parks with coupled energy networks addressing Complexity bottleneck through an Interdependence analysis, *Comput. Chem. Eng.*, 138, 106859, 2020

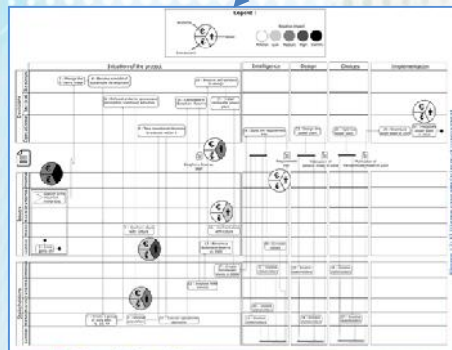
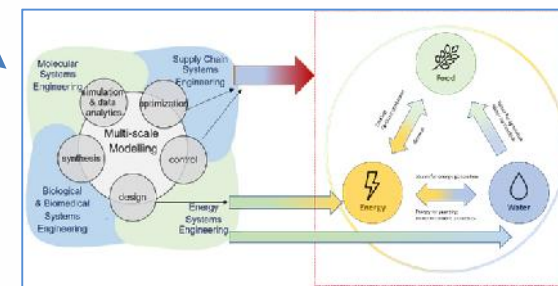


Fig. 5. Evaluation workshop using the indicator booklet (left photo) and evaluation matrix completed by participants with indicators, values judgments (coloured stickers) and weights (right photo).

S. ALLAIN, G. PLUMECOCQ, D. LEENHARDT, Linking deliberative evaluation with integrated assessment and modelling: a methodological framework and its application to agricultural water management. *Futures*. 2020

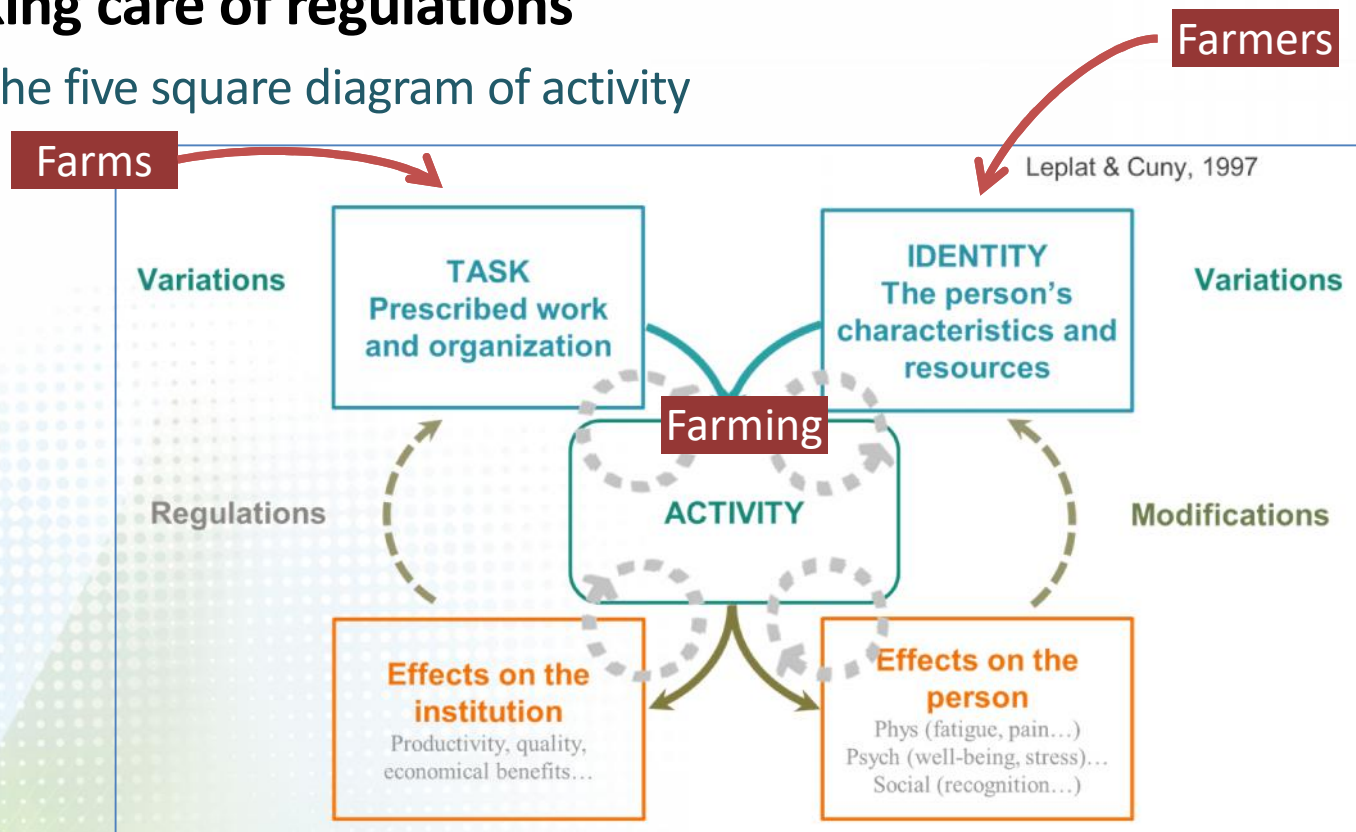


D. PENA-TORRES, M. BOIX, L. MONTASTRUC Optimization approaches to design water-energy-food nexus: a bibliographic review. *Submit. To Comput. Chem. Eng.* 2022



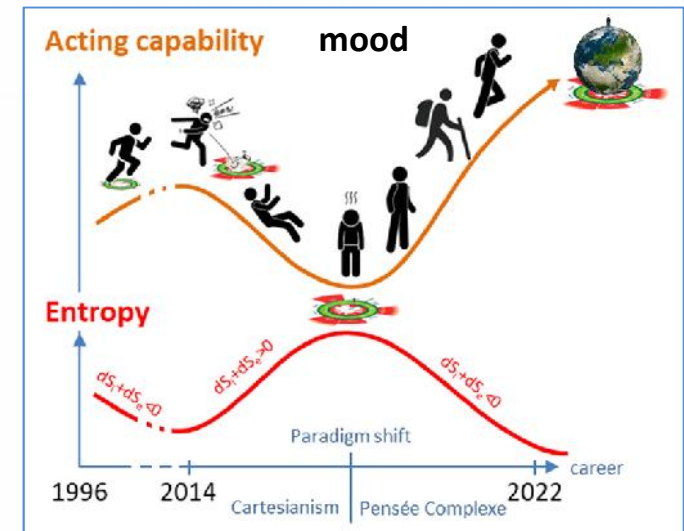
Some examples on the horizon

- **Mixing viewpoints**
 - Farms: architecture
 - Farmer: stakeholder-oriented
 - Farming: dynamic process oriented
- **Taking care of regulations**
 - The five square diagram of activity



My entropy sensor

- **Acting capability is increasing again!**
 - I still gain knowledge and expertise, $dU > 0$
 - T remains high as I explore new disciplines
 - Macroeconomy
 - Social entropy theories
 - Entropy change is globally ($dS = dS_i + dS_e$) < 0
 - I've made peace with myself
 - I still spend energy for learning, so $dS_i > 0$
 - $dS_e < 0$ since I have found new ways to disseminate knowledge, to conduct research....



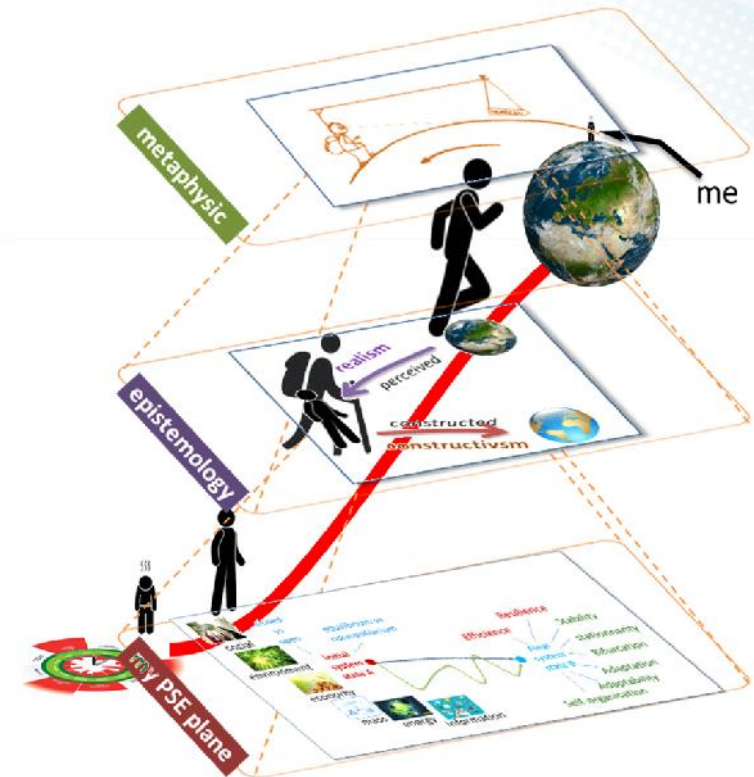
$$\text{So, } dF = (dU - T \cdot dS) > 0$$





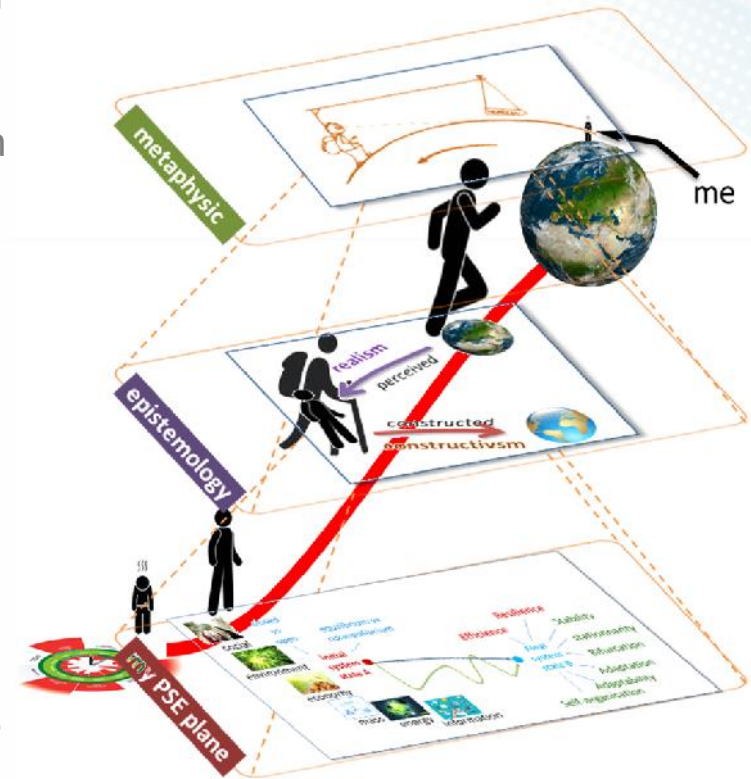
Guidelines & Conditions of change

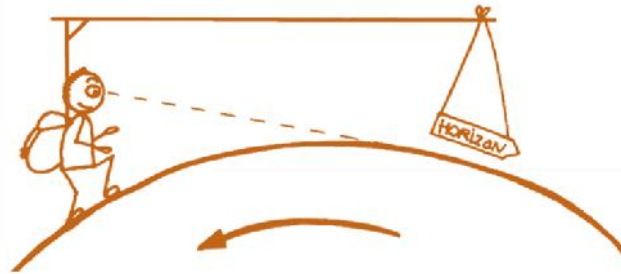
- **Be bold! think & act**
 - Practice “*acting-thinking in complexity*”
 - Connect, link, join, relate
 - Question the question
 - Reformulate the problem to be explored
 - Investigate contexts of any subject
 - Reveal implicits and untold
 - Pay attention to weak signals and feedback to adjust your progress along the path
 - Value the path more than the “*expected result*” so as to reach a ‘satisfactory result’
 - Do it with other people
 - Accept uncertainty
 - Accept contradiction
 - Redefine ways, means and ends
 - Bifurcate if necessary



Guidelines & Conditions of change

- **Shift!**
 - Metaphysical shift
 - Reassess your relationship within the current world
 - Epistemological shift
 - Shift from cartesianism to pragmatic constructivism
 - Methodological shift
 - Act on what is meaningful
 - Act on what matters for you and for the socio-ecological transitions
 - Look-up
 - Drop excellency, h-factor as the ruling mark
 - Shift from economy-first towards more environment and social
 - Value alternative ways of evaluating research activity
 - Build a collective environment favorable for change
 - Discuss with colleagues and family
 - » *Join academic activist groups*
 - Practice with human beings, not just with computers :
 - » *Interdisciplinarity, low-profile on your expertise*
 - » *Participative science with non-expert stakeholders*





As I walk along the uncertain path ahead, I'm confident that research approach embedded in La pensée Complexe is heading towards truly sustainable solutions meaningful for me

A moving path towards future

Confident and resolute

