



## From growth to sustainable bioeconomy: a new cylindrical conceptual framework

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## 6. The transition to a sustainable bioeconomy



### 6.1 Bioeconomy Systems

#### **From growth to sustainable bioeconomy: *a new cylindrical conceptual framework***

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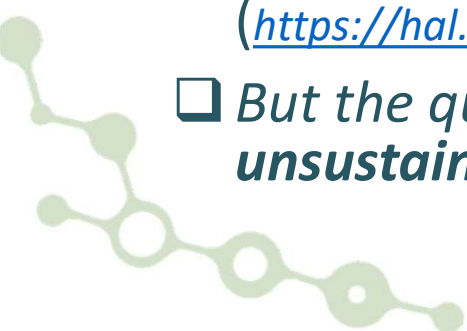
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## 6.1 Bioeconomy Systems

### Introduction: key considerations for sustainable bioeconomy systems:

- ☐ Sustainability defined by Brundtland in 1987
- ☐ Concept of bioeconomy introduced in 2002 with focus on biotechnology, then on resources bioeconomy and now on ecological bioeconomy
- ☐ Notion of boundaries by the Stockholm resilience centre: **radar** with planetary boundaries (Rockstrom et al, 2009)
- ☐ Notion of social lower limits: **doughnut** (Raworth 2017)
- ☐ EC sustainable *and circular* bioeconomy 2018
- ☐ In France, INRAE strategy focusing on complex, territorial bioeconomy systems (<https://hal.inrae.fr/hal-02866076>; <https://colloque.inrae.fr/bioeconomy2019/> )
- ☐ *But the question remains ‘when are bioeconomies sustainable or unsustainable?’*





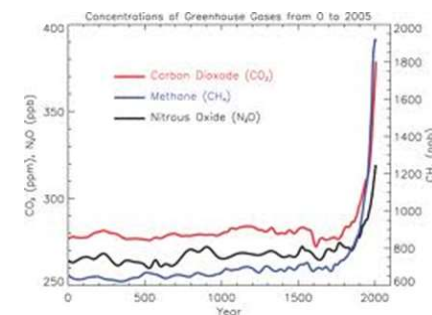
## 6.1 Bioeconomy Systems

### Methodology: fundamentals of sustainable bioeconomy systems

- (Sustainable) bioeconomy systems can be integrally represented by the **seven building blocks of game theory (I)**
- Bioeconomy systems are sustainable if they are continuously **evolving between order and chaos (II)**
- The evolution is then following **sinusoidal like patterns**, *and not continuous (linear, exponential,..) growth or decline ones;*

>> Combined sinusoidal patterns form **helices**, the most stable but dynamic configurations in nature **(III)**

- **(I) + (II) + (III)** result in a **conceptual framework**, of a **multiple cylinder configuration** with an inner rigid zone, a sustainable safe operating zone and outer chaos zone .

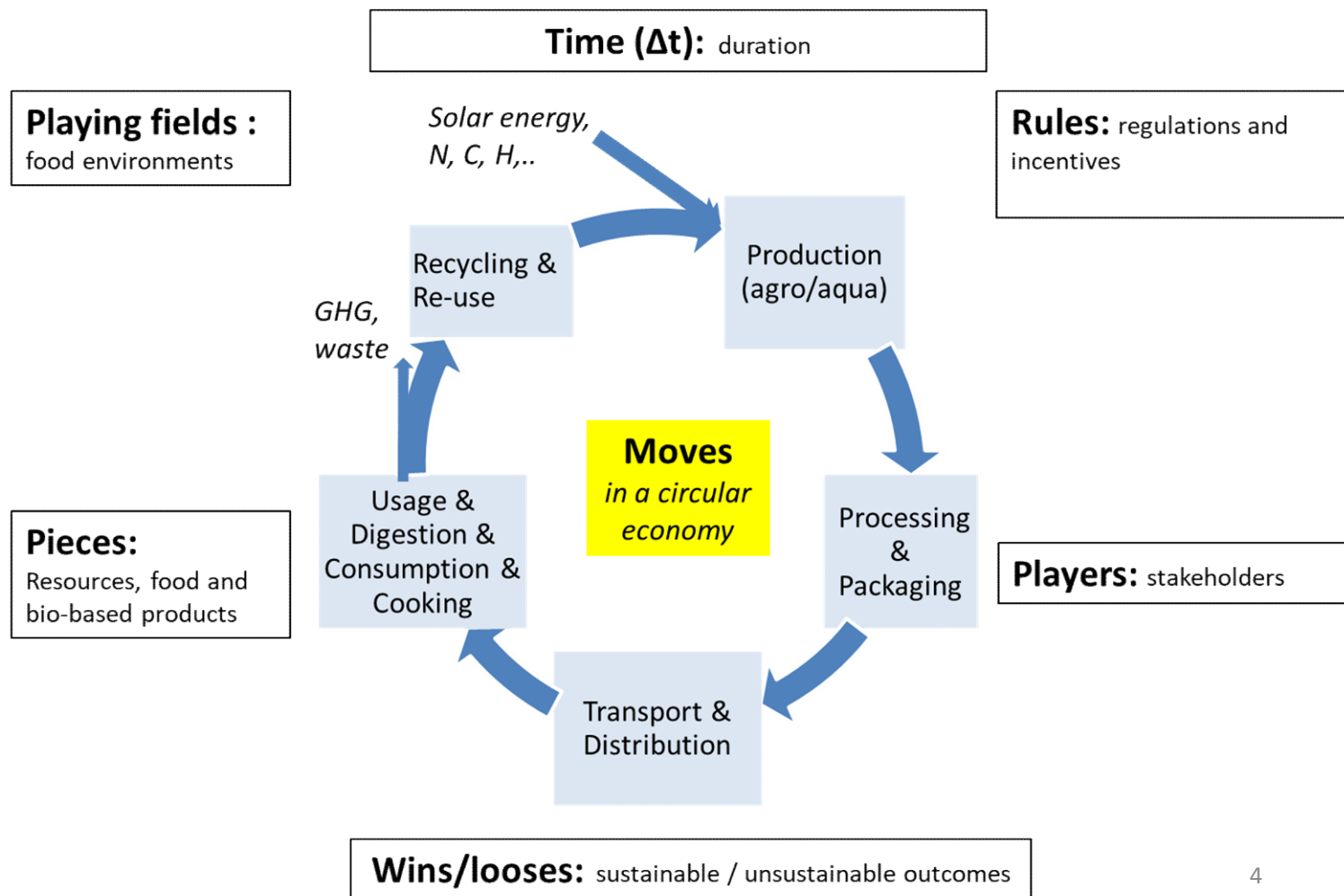


Today: exponential curves.  
Source: [Intergovernmental Panel on Climate Change](#).

Tomorrow: a need for balancing curves.

## 6.1 Bioeconomy Systems

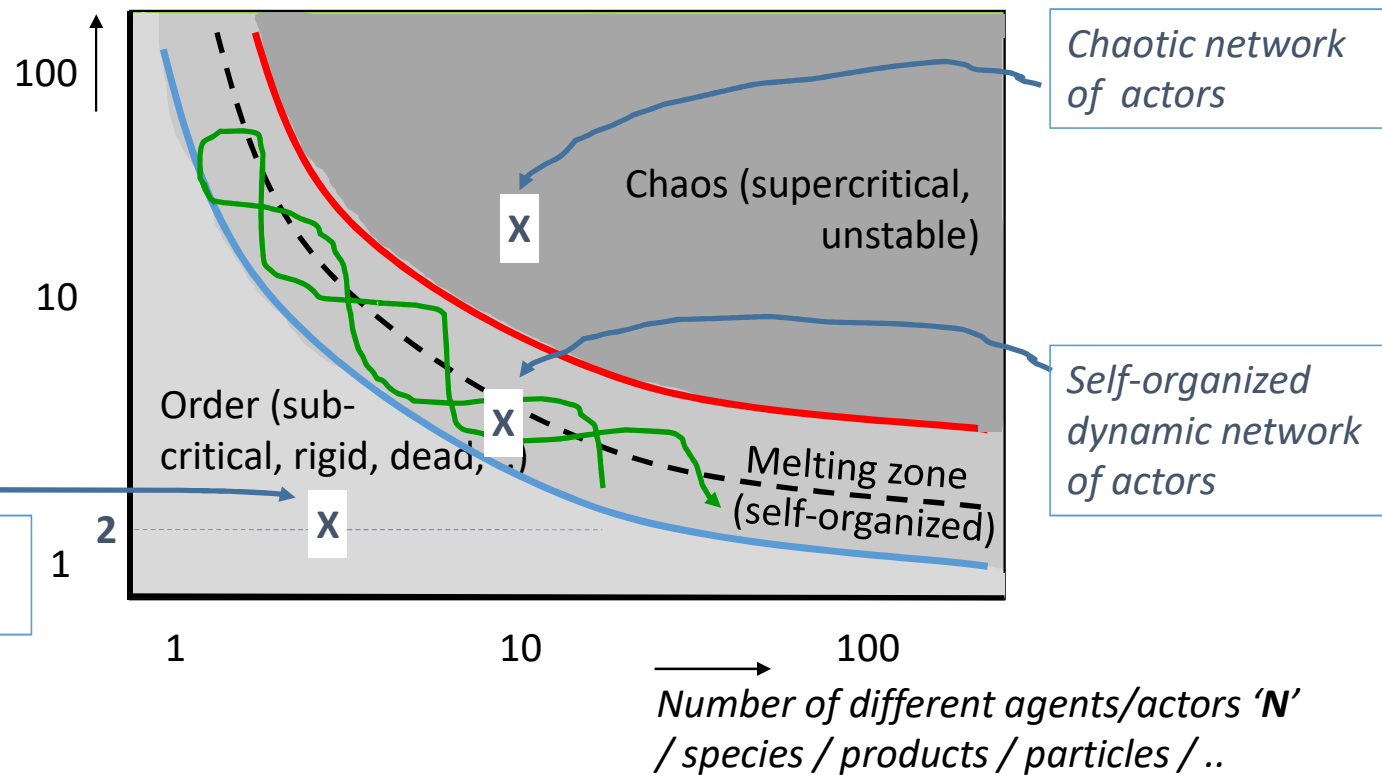
**(I)** : the 7 'building blocks' of 'systems' or 'game theory' are integrally describing (sustainable) bioeconomy systems



## 6.1 Bioeconomy Systems

**(II)**: sustainable bioeconomy systems are balancing in the melting zone between order and chaos

Interactions ' $K$ ' between agents / actors / species / products / particles / ..



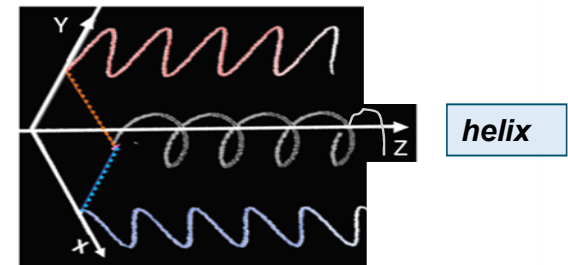
## 6.1 Bioeconomy Systems

(III): sustainable bioeconomy systems are revealing sinusoidal patterns which are jointly resulting in helices, very stable but dynamic configurations



**Behavior of Players** (y-axis)

**Utilization of pieces** (x-axis)



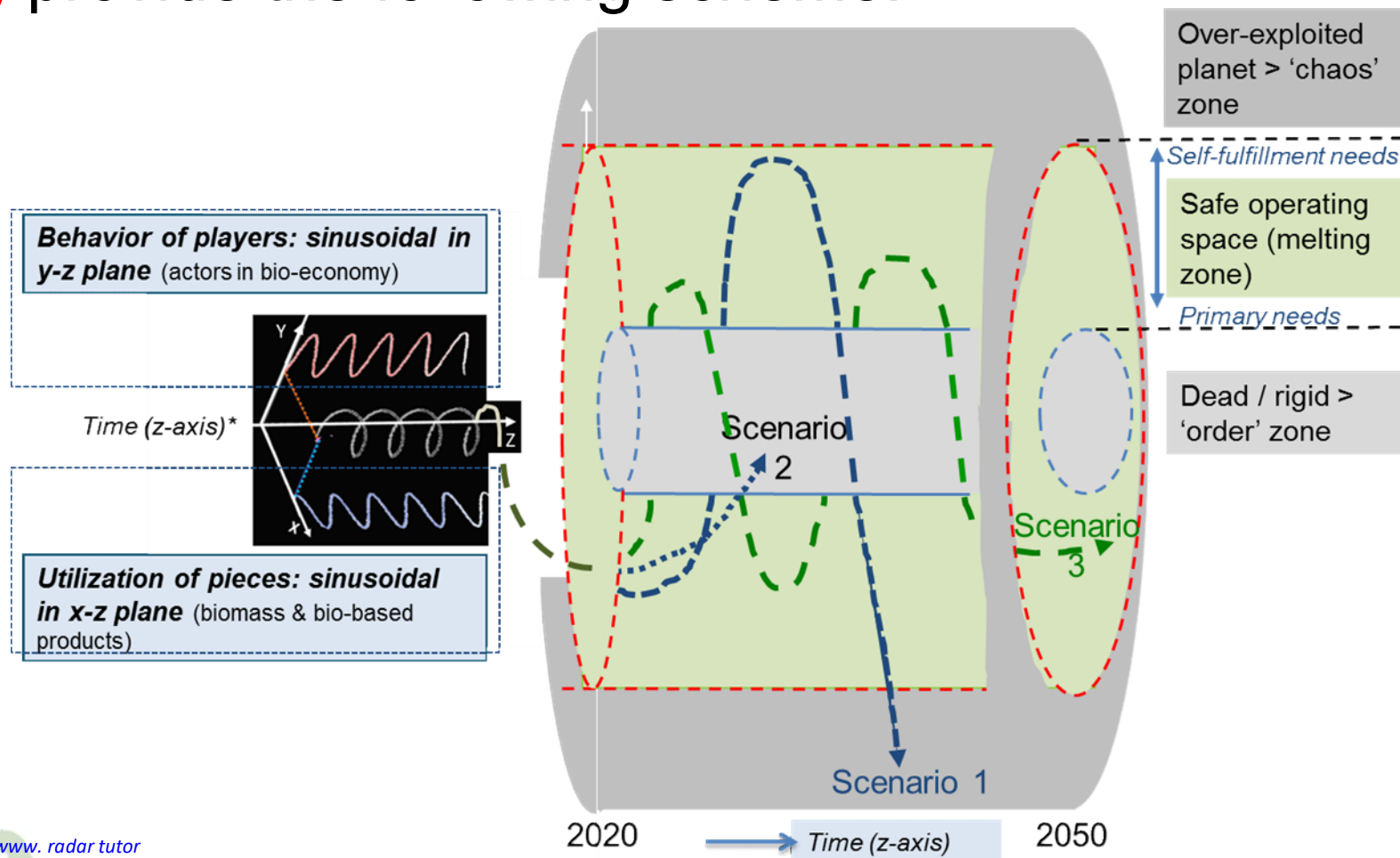
**The helix is the sum of sinusoidal curves of the behavior of players and utilization of pieces/products**

Source: Modified image of <https://www.radar-tutorial.eu/06-antennas/pic/zirkulanim.gif> is included



## 6.1 Bioeconomy Systems

(II)+(III) provide the following scheme:





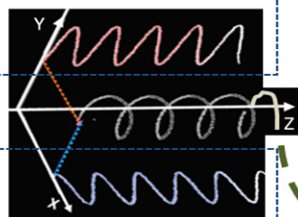
## 6.1 Bioeconomy Systems

**(I)+(II)+(III)** provide a new conceptual framework

Graphic representation of system building blocks & helical pathways evolving in between boundaries

**Behavior of Players** (y-axis; actors in bio-economy)

Time (z-axis)\*



**Pieces utilization:** (x-axis; biomass & bio-based products)

**Rules** (defining the freedom, rights & obligations)

**Moves**  
(all activities transforming resources into products)

**Playing fields**

Over-exploited planet > 'chaos' zone

Self-fulfillment needs

Safe operating space (melting zone)

Primary needs

Dead / rigid > 'order zone'

Scenario 2

Scenario 3

Scenario 1

2020

Time (z-axis)

2050

**Scenarios:**

**WIN** (--->): '3'

**LOSE** (---->): '1' and '2'

Adapted from own publication:  
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## 6.1 Bioeconomy Systems

# Verification of the appropriateness of the conceptual framework via case studies

**Case study:** valorization of agricultural waste and by-products > towards biogas and beyond:



- Moves: From farm to modern biogas company and now beyond: Recycling, bioenergy conversion, bio-fertilizer manufacturing
- Pieces: Biogas, dried fertilizer, other products in consideration; resources 'manure', by-products from vegetables, fruit and energy crops
- Players: Network of entrepreneur, local farmers, eco-villagers (heat), Town Hall, logistic suppliers and distributors (for targeted fertilizers), e-car holders (sharing electricity)
- Playing field: territorial scale, relatively well defined, since ~2000
- Rules & constraints: National legislation & subventions, limitation for feed-in tariffs, odors, local appreciation,
- Outcomes: technological, business & social innovations; valorization of organic waste, new products & markets for local producers, jobs created.

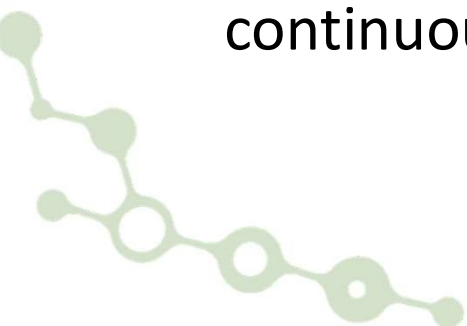


## 6.1 Bioeconomy Systems

# Is 'the case' sustainably evolving?

Our observations are:

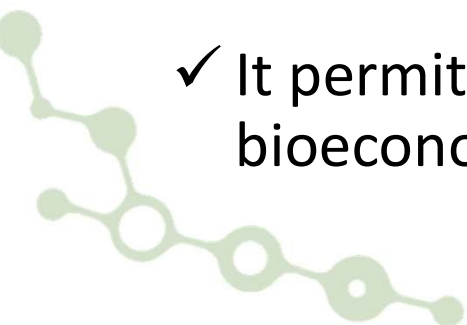
- The case integrally considers all 7 'building blocks' of game theory.
- The business activities are between (order-chaos) limits, impacted by rules (e.g. no landfill, subventions,...); and tend to show helical patterns.
- The outputs seem to be sustainable in all three pillars (PPP), thanks to combined business, social & technological innovations.
- The case ('a bioeconomy system') seeks to sustainably evolve by continuously adapting and innovating all building blocks coherently.





# Conclusions

- ✓ The conceptual framework seems to cover all 'building blocks' of sustainable bioeconomy (sub-)systems and allows following their evolution pathway.
- ✓ In particular it dynamically connects system 'building blocks', taking into account regulations and geographical dimensions.
- ✓ An extensive analysis has been possible for 8 cases
- ✓ It permits to draw policy options for (territorialized) sustainable bioeconomy systems.





## 6.1 Bioeconomy Systems

Thank you very much for your attention

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<https://colloque.inrae.fr/bioeconomy2019/Programme2> & <https://gbs2020.net>

