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► To cite this version:

Hugo de Vries, Mechthild Donner, Monique Axelos. From growth to sustainable bioeconomy: a new cylindrical conceptual framework. 3rd International Bioeconomy Congress Baden-Württemberg, Sep 2020, online, Germany. hal-03210026

HAL Id: hal-03210026

<https://hal.inrae.fr/hal-03210026>

Submitted on 27 Apr 2021

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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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21 – 22 September 2020, Hohenheim, Germany



This work is published as:

de Vries, H., Donner, M. & Axelos, M. (2021). A New Conceptual 'Cylinder' Framework for Sustainable Bioeconomy Systems and Their Actors. J Agric Environ Ethics 34, 11. <https://doi.org/10.1007/s10806-021-09850-7>



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?’*

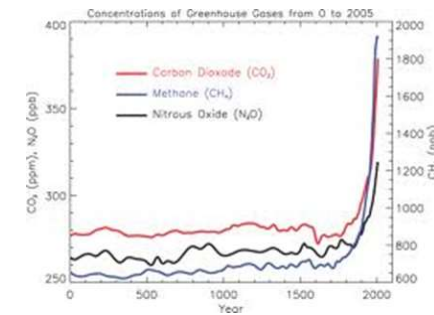
6.1 Bioeconomy Systems

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 .

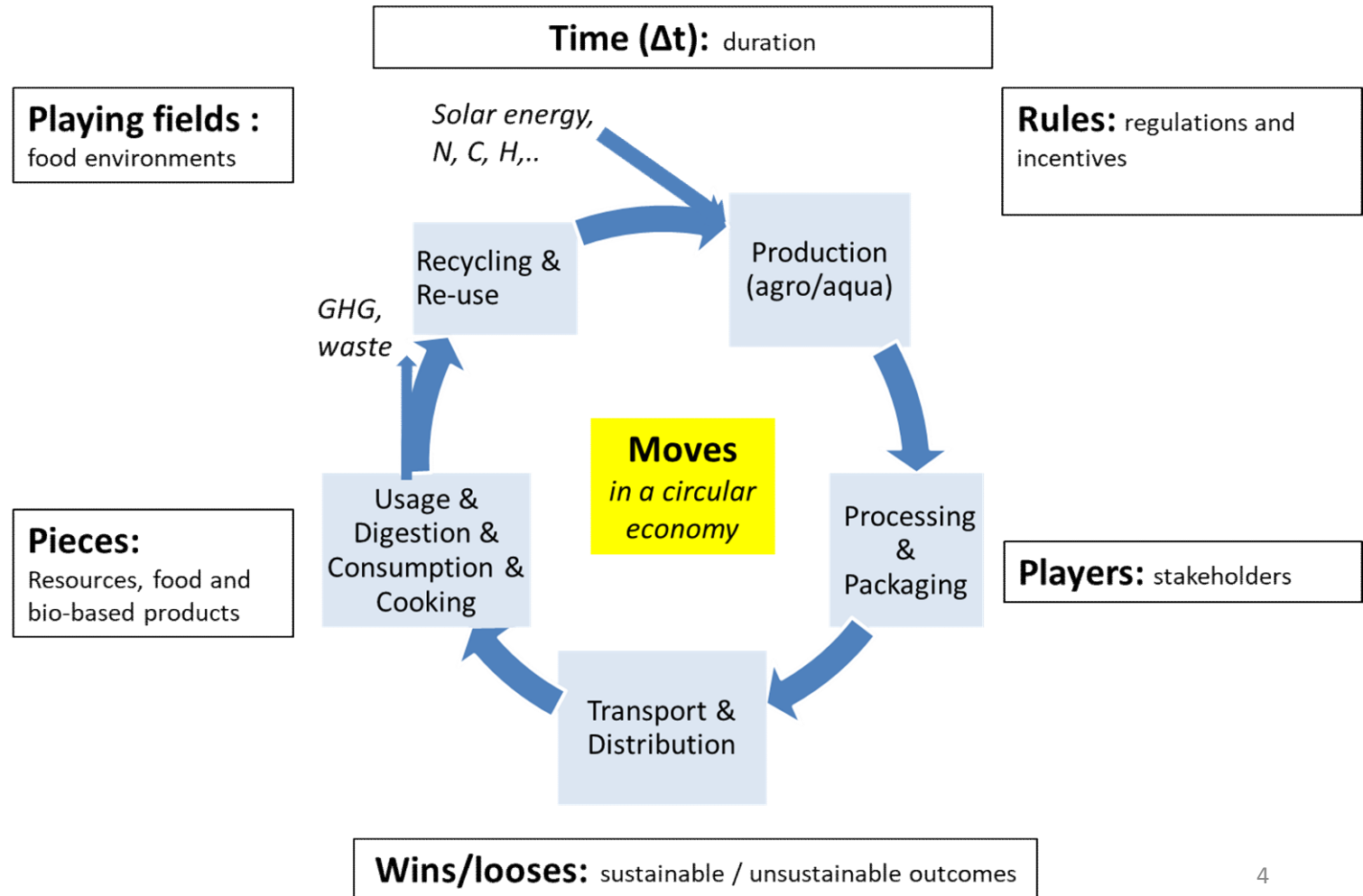


Today: exponential curves.
Source: [Intergovernmental Panel on Climate Change](#).

Tomorrow: a need for balancing curves.

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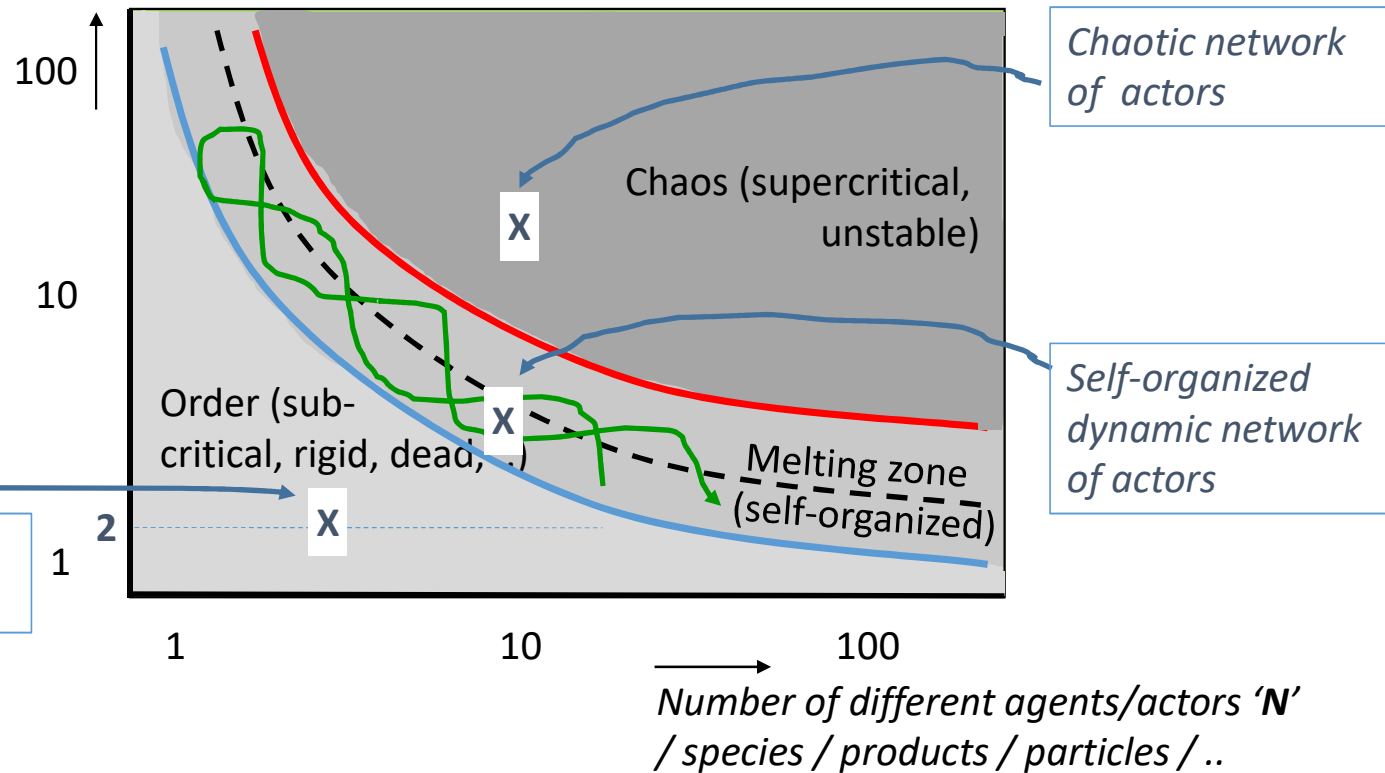
(I) : the 7 'building blocks' of 'systems' or 'game theory' are integrally describing (sustainable) bioeconomy systems



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

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



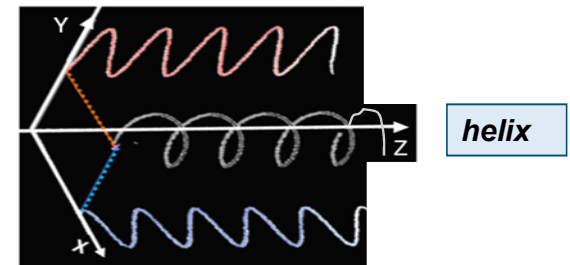
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(III): sustainable bioeconomy systems are revealing sinusoidal patterns which are jointly resulting in helices, very stable but dynamic configurations



Behavior of Players (y-axis)

Utilization of pieces (x-axis)

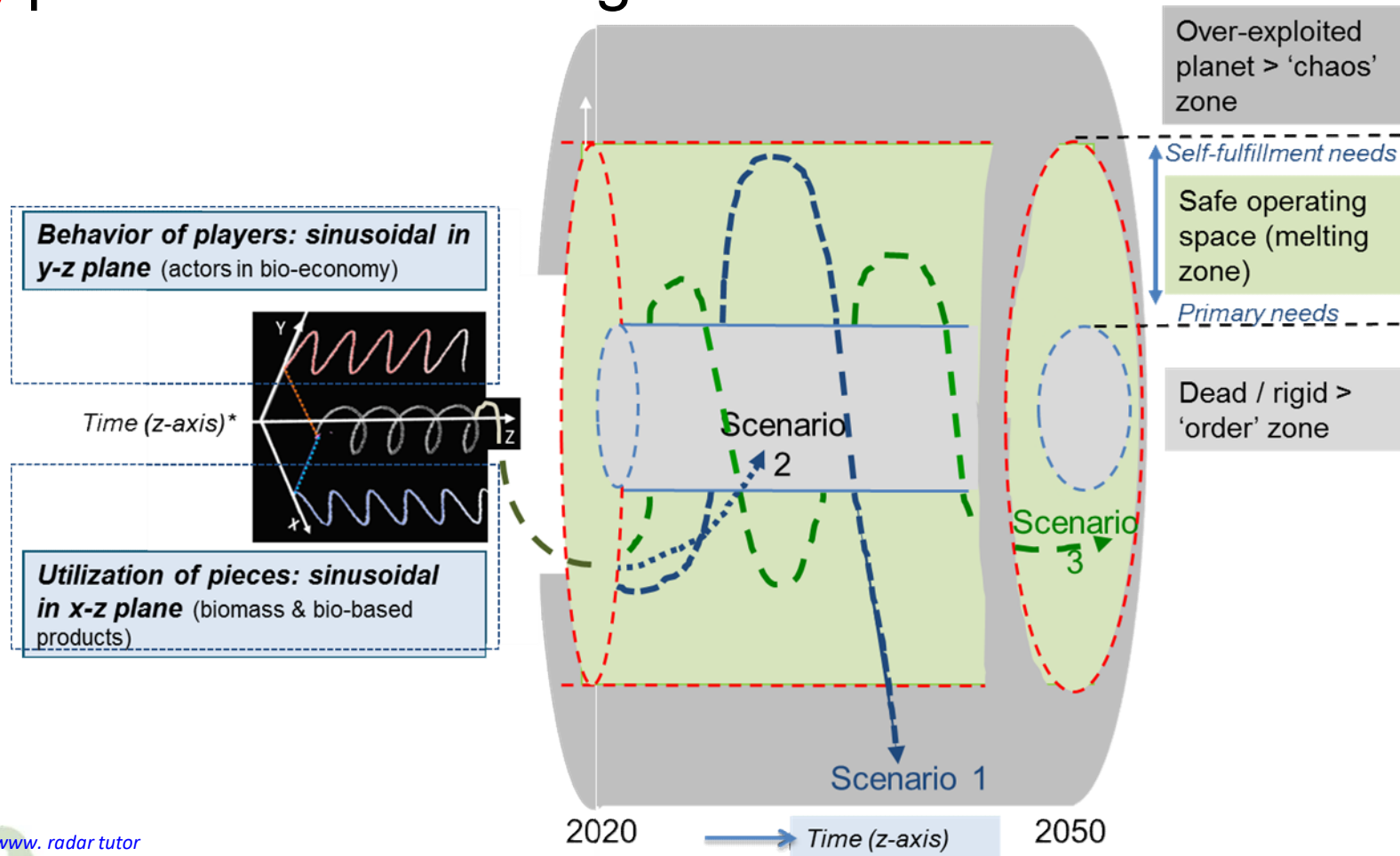


The helix is the sum of sinusoidal curves of the behavior of players and utilization of pieces/products

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

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



Source: Modified image of <https://www.radar.tutorial.eu/06.anten.nas/pic/zirku.lanim.gif> is included



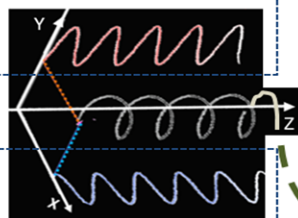
6.1 Bioeconomy Systems

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

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



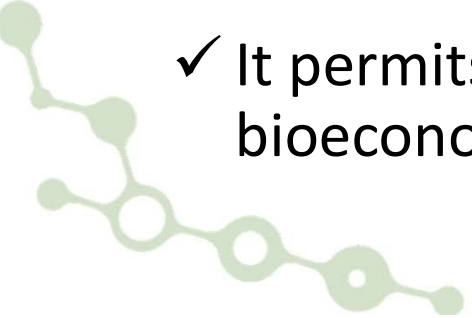
- Moves: From farm to modern biogas company and now beyond: Recycling, bioenergy conversion, bio-fertilizer manufacturing
- Pieces: Biogas, dried fertilizer, other products in consideration; resources 'manure', by-products from vegetables, fruit and energy crops
- Players: Network of entrepreneur, local 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.

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.
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Thank you very much for your attention

<https://www.inrae.fr/en/bioeconomy>

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

