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Hugo de Vries, Mechthild Donner, Monique Axelos

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3. BIOECONOMY CONGRESS BADEN-WÜRTTEMBERG

6.1 Bioeconomy Systems

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

Hugo de Vries[1,3], *Mechthild Donner*[2] *and Monique Axelos*[1]
[1] INRAE, DS Food and Bioeconomy
[2] INRAE, UMR MOISA
[3] INRAE, UMR IATE
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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?'***

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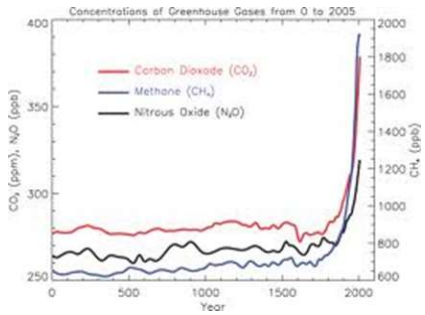
Methodology: fundamentals of sustainable bioeconomy systems

- (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 **.**

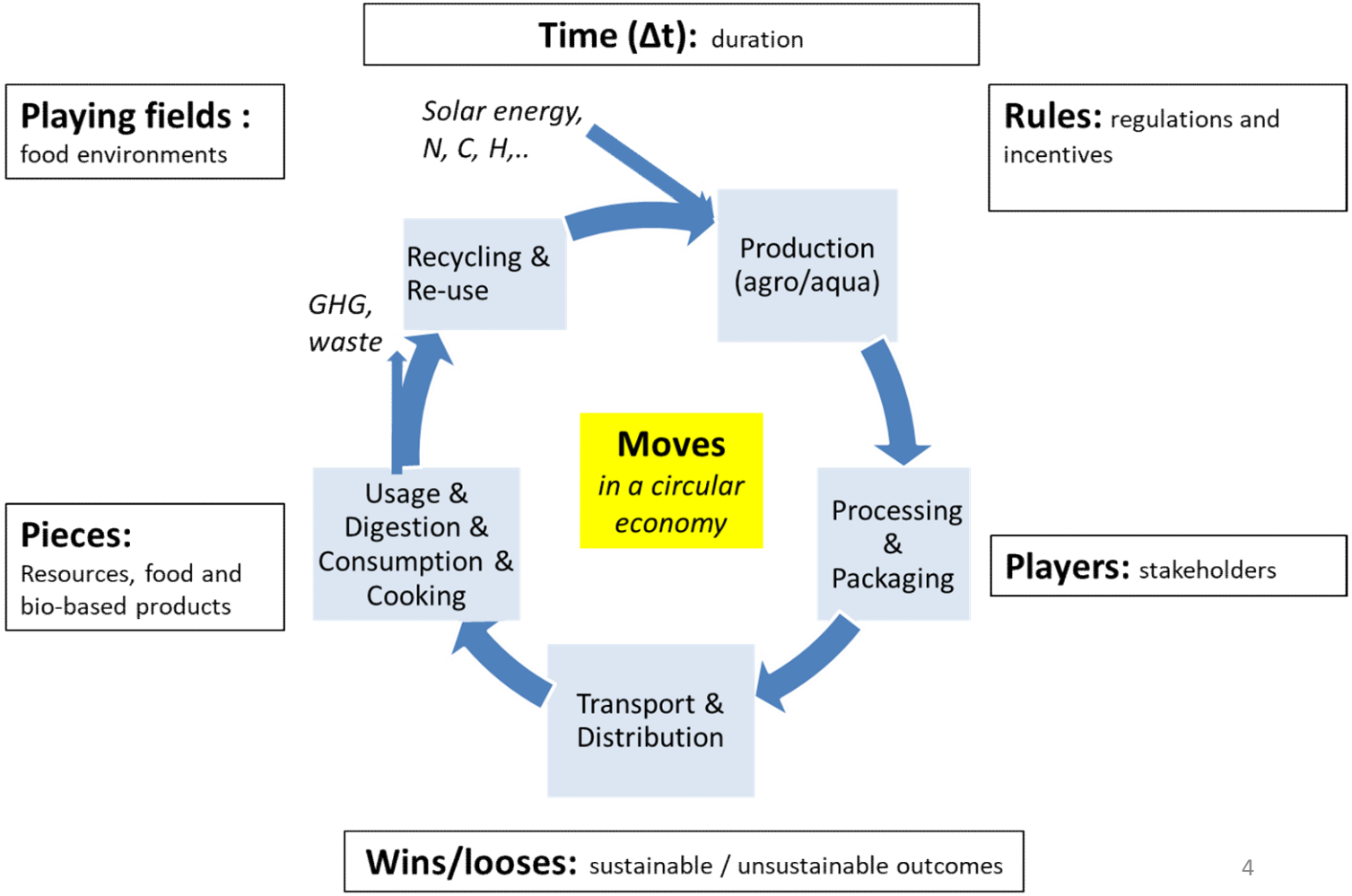


Today: exponential curves.
Source: [Intergovernmental Panel on Climate Change](#).

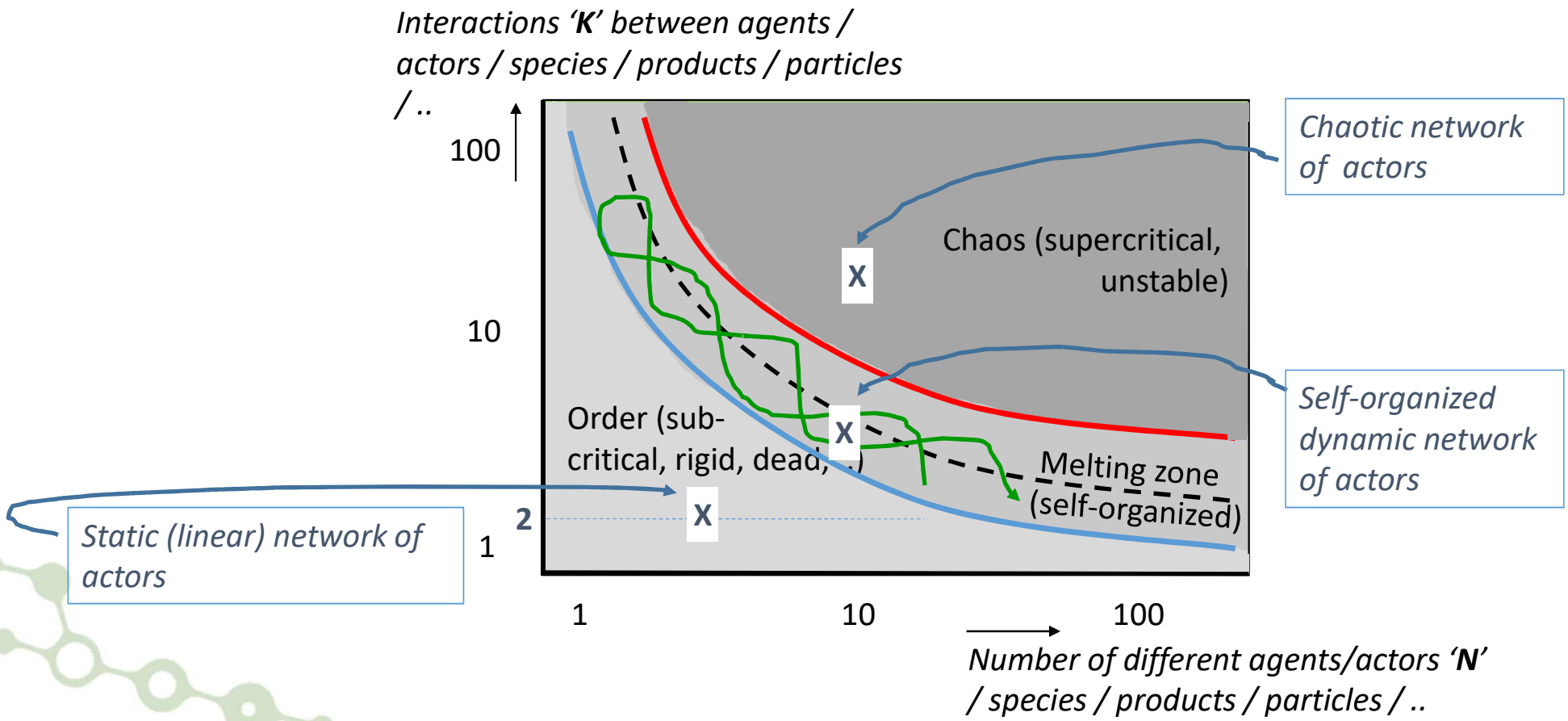
Tomorrow: a need for balancing curves.

6.1 Bioeconomy Systems

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



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



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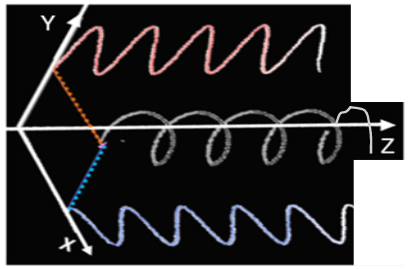
(III): sustainable bioeconomy systems are revealing sinusoidal patterns which are jointly resulting in helices, very stable but dynamic configurations

Behavior of Players (y-axis)



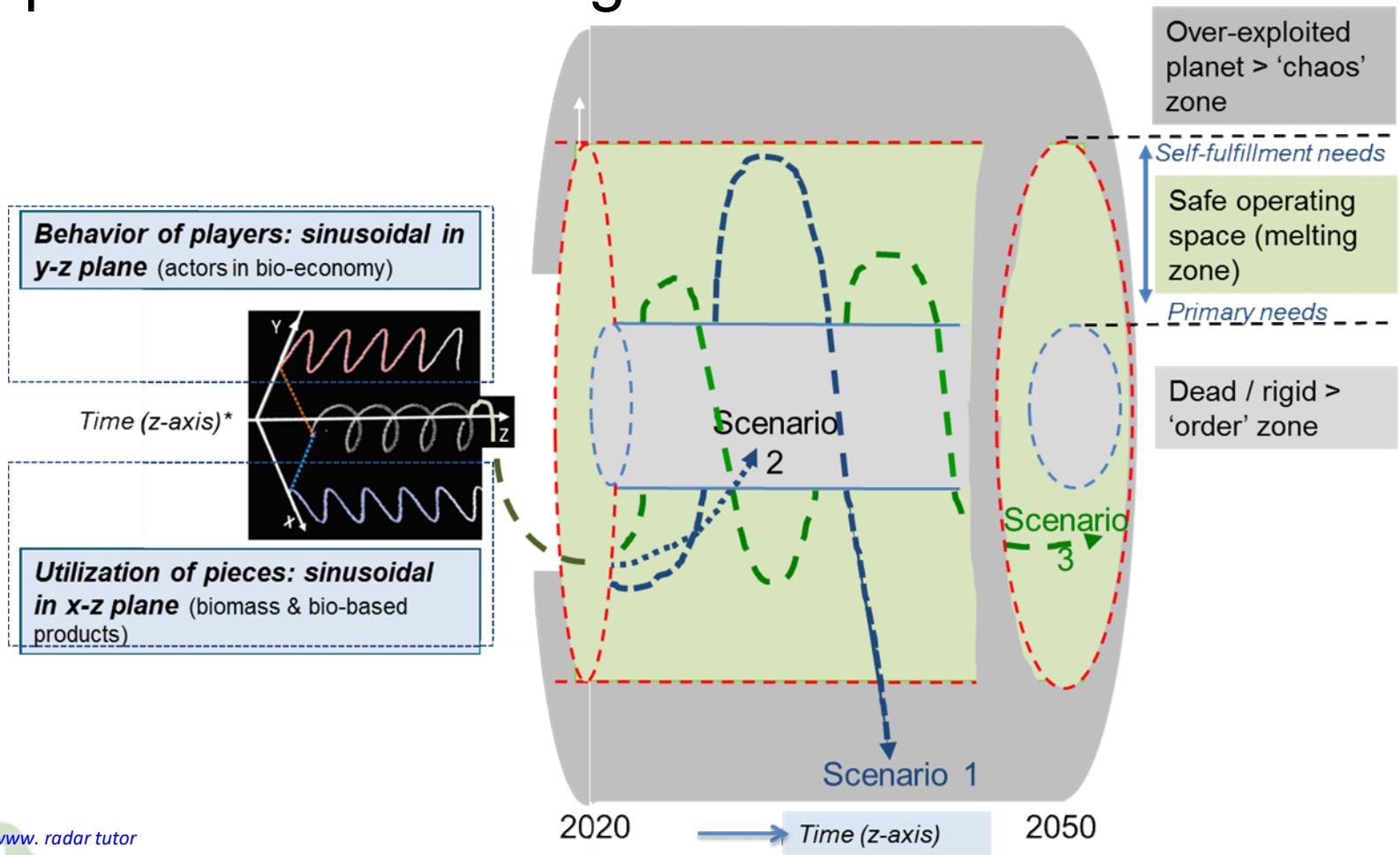
helix

Utilization of pieces (x-axis)

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

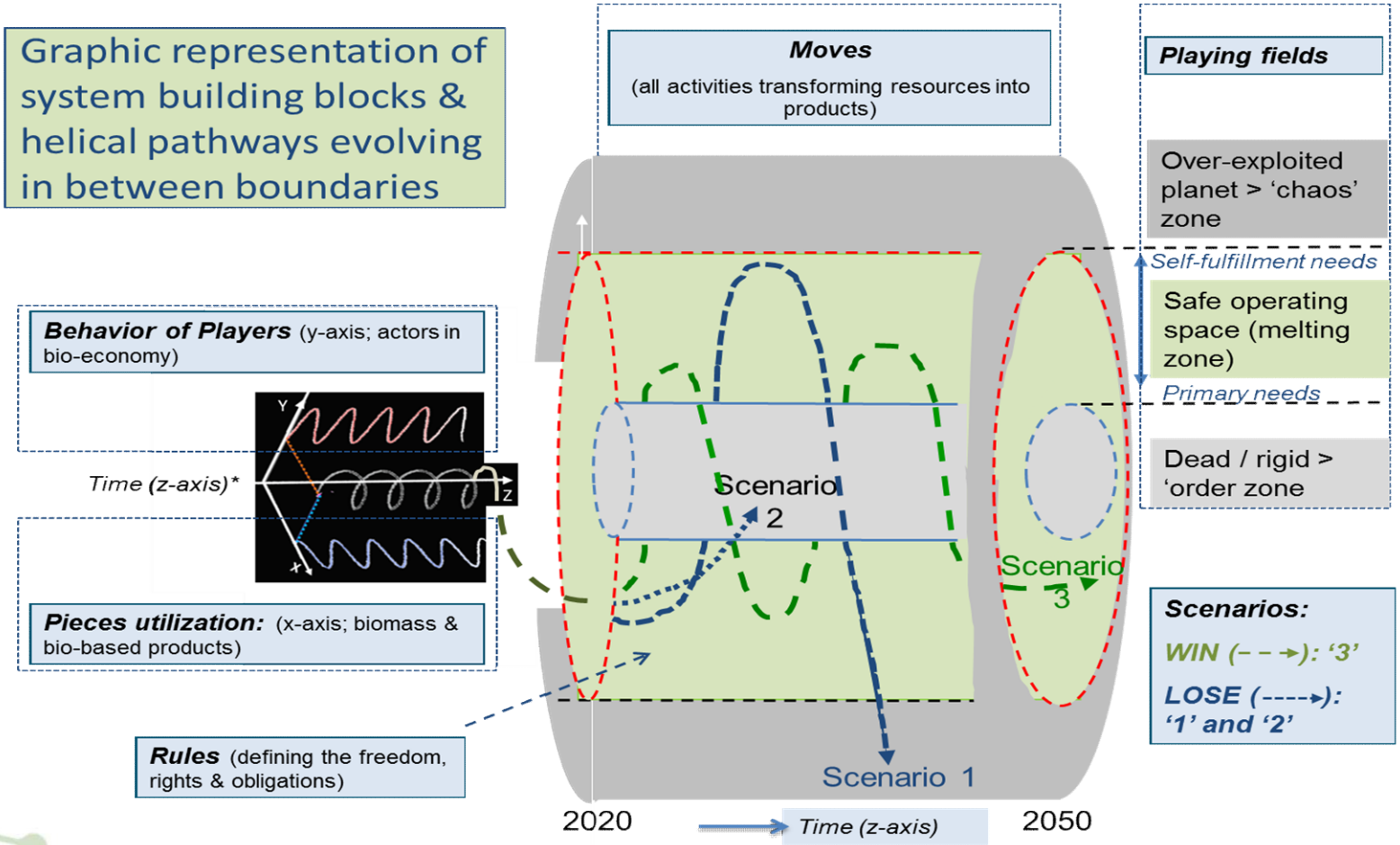
Source: Modified image of https:// www. radar tutor ial. eu/ 06. anten nas/ pic/zirku lanim. gif is included

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



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

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



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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-inn tariffs, odors, local appreciation,
- Outcomes: technological, business & social innovations; valorization of organic waste, new products & markets for local producers, jobs created.

*Ref. https://noaw2020.eu/ and Donner et al. (2020) https://hal.inrae.fr/**hal-02624927**/document*

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.

Thank you very much for your attention

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

hugo.de-vries@inrae.fr

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