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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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?’
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.
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.
(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.radarutorial.eu/06. antenas/pic/zirku_lanim.gif is included
(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

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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.

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