INNOVATION ECOSYSTEMS OF SECOND-GENERATION ETHANOL (SELECTED AB3E PAPER)

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Overview

Concerns regarding the environmental consequences of greenhouse gas (GHG)emissions have led several countries to redefine their economies to achieve more sustainable goals. In order to meet transportation energy demands, biofuels emerge as one of the main solutions. Ethanol has been the most widely used biofuel in the world (BP, 2017), but its sustainable expansion in decarbonization scenarios requires its production through advanced technologies (IEA, 2017), as the second-genaration (2GE), obtained from non-food raw materials such as sugarcane bagasse and straw.

2GE industry is characterized as innovative with important structuring challenges. The concept of Innovation Ecosystems (IE) can contribute to the understanding of this process. An IE is a set of collaborative and competitive arrangements through which companies from different knowledge domains combine their individual offerings into a coherent customer-focused solution (Moore, 1993).

Considering the increasingly urgent sustainability goals, it is important to question the structuring processes of these new industries. What are their main challenges? How are they being faced? Therefore, the objective of this research is to understand how the 2G ethanol industry structuring process has been developing in order to identify its main challenges and forms of competition and cooperation. These results are intended to assist decision makers and entrepreneurs in the development of a low carbon economy.

Methods

To achieve the proposed objectives, a case study methodology was conducted. Primary sources of consultation were 570 **articles** from 56 biofuel related sites. The six companies in the sector that had commercial plant were analysed (Table 1).Then two rounds of semi-structured interviews were conducted with industry experts, one to triangulate the information obtained from other sources (set of materials, events and articles) and another to validate with the experts the built ecosystems. A total of 10 interviews were conducted from May 2017 to December 2018.

Table 1: 2G Etanol Commercial Projects

Granbio	**Raízen**	**Poet-DSM**	**Beta Renewables**	**Abengoa**	**Dupont**
S. João dos Milagres, Brazil	Piracicaba, Brazil	Emmetsburg, USA	Crescentino, Italy	Hugoton, USA	Nevada, USA
Capacity (millions of liters/ano)					
82	40	94	75	95	113
CAPEX (millionsofdolars)					
265	100	275	210	500	225
Raw Material					
Sugarcanestraw	sugar cane bagasse	Corn straw	Wheat straw	Corn straw	Corn straw
Conversion Technologies					
Pre-Treatment					
Steam explosion	Diluted acid	Diluted acid	Steam explosion	Diluted acid	Alkali
Hydrolysis					
Enzymatic (SSFC)	Enzymatic (SSFC)	Enzymatic (SSF)	Enzymatic (SSFC)	Enzymatic (SSF)	Enzymatic (SSF)
Yeast					
DSM	Iogen	DSM	Leaf Technologies	Abengoa	Dupont

Status					
Active	Active	Active	closed	closed	closed

Results

The main results are summarized in Table 2.

Table 2: Lessons from the 2G Ethanol Case Study

Dimension[1]	**Result**	**Importants Aspects**
Evolutionary Stage	Birth	**Cooperation** between focal ecosystems played a more relevant role than competition. Companies sought cooperation to address key challenges posed by innovation.
Strategy	Focal Ecosystem	Beta Renewables, Granbio, Raízen e Abengoa - **keystone**. Dupont e Poet-DSM - **domination**
Challenges	Components	Favorable to create **competitive advantage**,considering that the challenges will be overcome.
Structure	Factors that influence IS structure	The **type** and **origin** of companies influence the structure of ecosystems. The role that is attributed to 2G ethanol varies according to the company's origin, also influencing its strategy.
Value Blueprint	Reconfiguration need	Raízen e Granbio – **Reconfiguration** need. Poet-DSM just reconfigured its structure.

The analysis of the 2G ethanol case showed a structuring industry that seeks to reduce its co-innovation risks through partnerships to surpass key steps in the new process. However, such partnerships were not sufficient to address unforeseen challenges, even though they were projects on a commercial scale - which is often considered to be the final stage of the innovation process. To address these challenges, companies needed to restructure their IEs by replacing/adding partners and reducing their **carryover ecosystems** to **Minimum Viable Ecosystems** (MVE).

Conclusions

The results allow us to identify important aspects in structuring renewable resource-based industries for sustainable energy production, particularly for the case of biofuels. The main challenges are related to raw material change and industry intersectoriality, two characteristics present in various sectors that seek to reduce their carbon footprints. The consequences of these challenges (company closures, research redirection) as well as the ways used by the companies to address them (ecosystem restructuring), serve as references for researchers and entrepreneurs alike in their quest for risk mitigation in the process of innovation in renewable resource-based industries.

References

BP. 2018. BP Statistical Review of World Energy. Junho de 2018.
IEA, 2017. International Energy Agency. Delivering Sustainable Bioenergy. 2017.
MOORE, J. F. Predators and Prey: a new ecology of competition. *Harvard Business Review*. v.71, n.3, p.75-86. 1993.

[1]The dimensions of IEs were identified from the ten most cited articles about the IE construct, namely: structure, evolutionary stage, strategies, location of challenges and value blueprint.