ABTCP 2015 48º CONGRESSO E EXPOSIÇÃO INTERNACIONAL DE CELULOSE E PAPEL

48º CONGRESSO INTERNACIONAL DE CELULOSE E PAPEL
1ª CONFERÊNCIA IBEROAMERICANA SOBRE BIOECONOMIA

DUE DILIGENCE FOR SUGAR PLATFORM BIOREFINERY PROJECTS: TECHNOLOGY RISK

UNICAMP

Adriano P Mariano

Assistant Professor
School of Chemical Engineering
UNICAMP

REALIZAÇÃO ABTCP

CORREALIZAÇÃO IPEF

Content overview

- Technology risk and sugar platform biorefinery projects

- Playing the role of technology buyers (pulp mills): implications and assessment of technology risk

What went wrong !?!

RIP Cobalt Technologies or…How Commercializing Butanol Technology is Like Riding the Tour de France

June 24, 2015 | Jim Lane

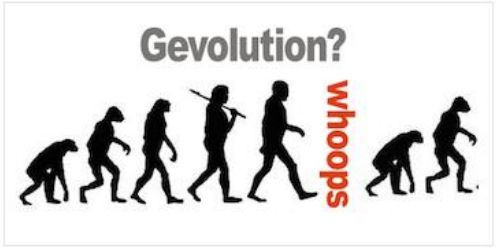
By Sam Nejame & James Evangelow, special to The Digest

BiofuelsDigest
The world's most widely read biofuels daily

Gevolution 2014: Gevo's forward progress, and some side-by-side

March 27, 2014 | Jim Lane

…The company switched "back to ethanol" once before, in fall 2012, at the time its **contamination difficulties were becoming more apparent at scale**.



What's up with Solazyme? Stock free-falls after Moema ramp-up delayed

November 6, 2014 | Jim Lane

…"the downstream process will require continued work to establish consistent, fully integrated operations."

Contamination! and other crises: 12 Signs that your favorite biofuels venture may be in trouble

December 18, 2012 | Jim Lane

Commercializing advanced biotechnologies: doing it successfully

- **Many risks** are found in moving first-of-a-kind-technologies from benchtop to commercial operation

- Most **new technologies** emerge as a new pathway that is "light-years" ahead of the way things are currently done

DEVELOPMENT AND SCALE-UP

- **Process Development – *It's not all about you***

- **Integrating Standard Unit Operations – *Standard industrial processes are never standard***

By Mark Warner, P.E, Founder, Warner Advisors
July 2015

BiofuelsDigest
The world's most widely read biofuels daily

Lifecycle of commercialization:

from scientific discovery to commercial deployment

Multiple stages of R&D and testing capabilities

Bench scale → Small Pilot → Integrated → Commercial

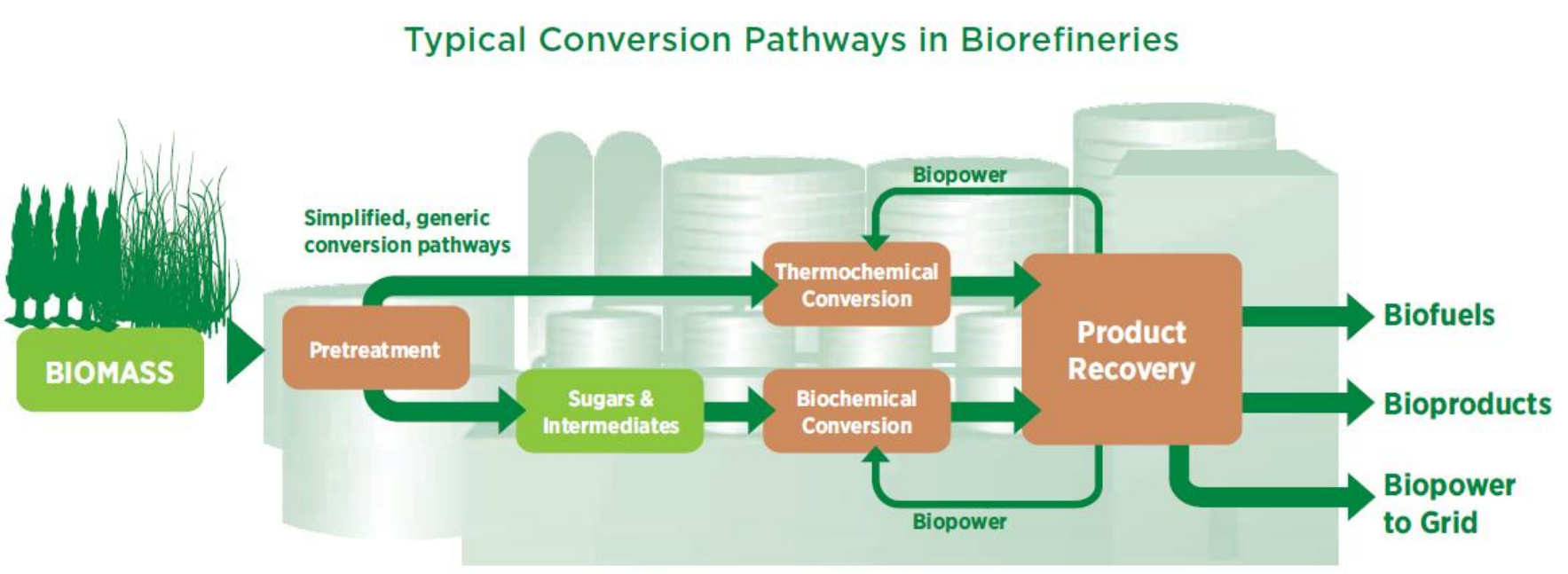
	Bench scale	Small Pilot	Integrated	Commercial
Objective	Early-stage innovation	Refine design basis	Test at pilot scale	Commercial production
Functional focus	Chemistry	Engineering	Systems integration	Operations
Operations	Batch 200 g	Continuous 1.5 kg/hr	Continuous 10 kg/hr	Continuous 1 to 10 t/hr
Number of runs	1500+	170+	50+	N/A

Bringing confidence in design, commercial results, and economics

17

coolplanet ENERGY SYSTEMS

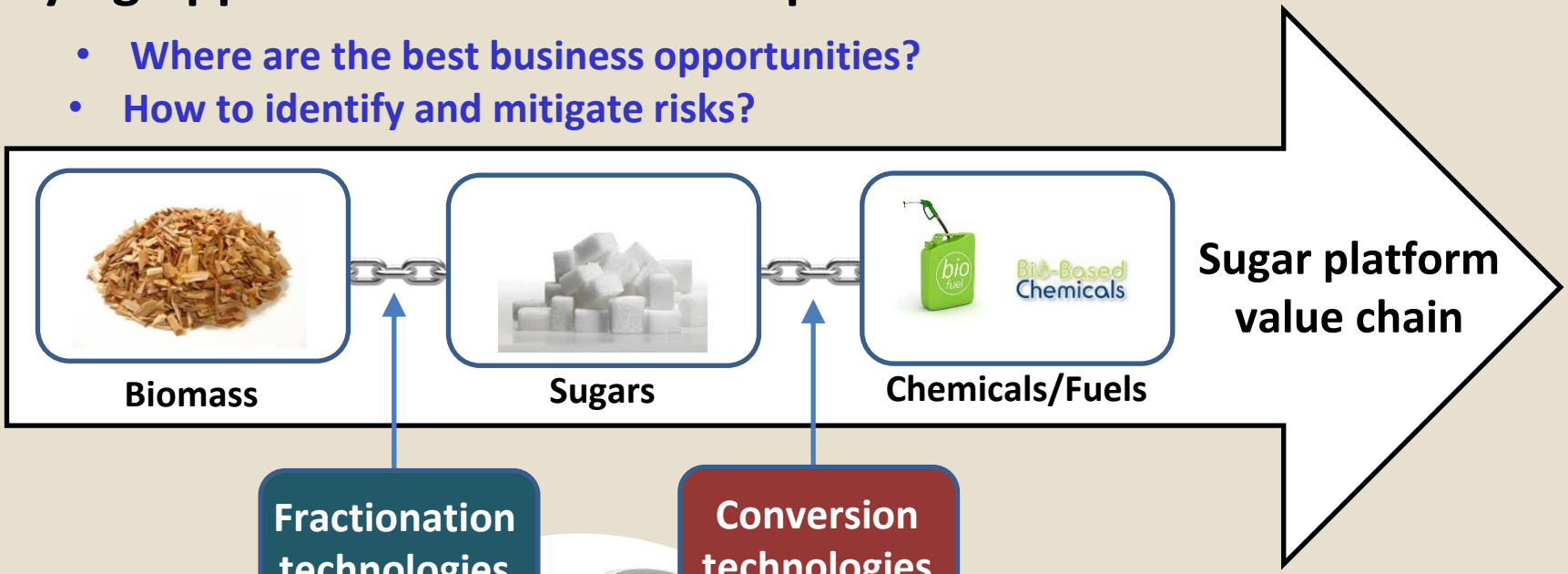
Biorefinery platforms



U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Identifying opportunities and risks implicated

- Where are the best business opportunities?
- How to identify and mitigate risks?



Technology buyer
(critical view)
x
Technology developer
(optimist)

Integration

Existing and new pulp mills

Sugar platform

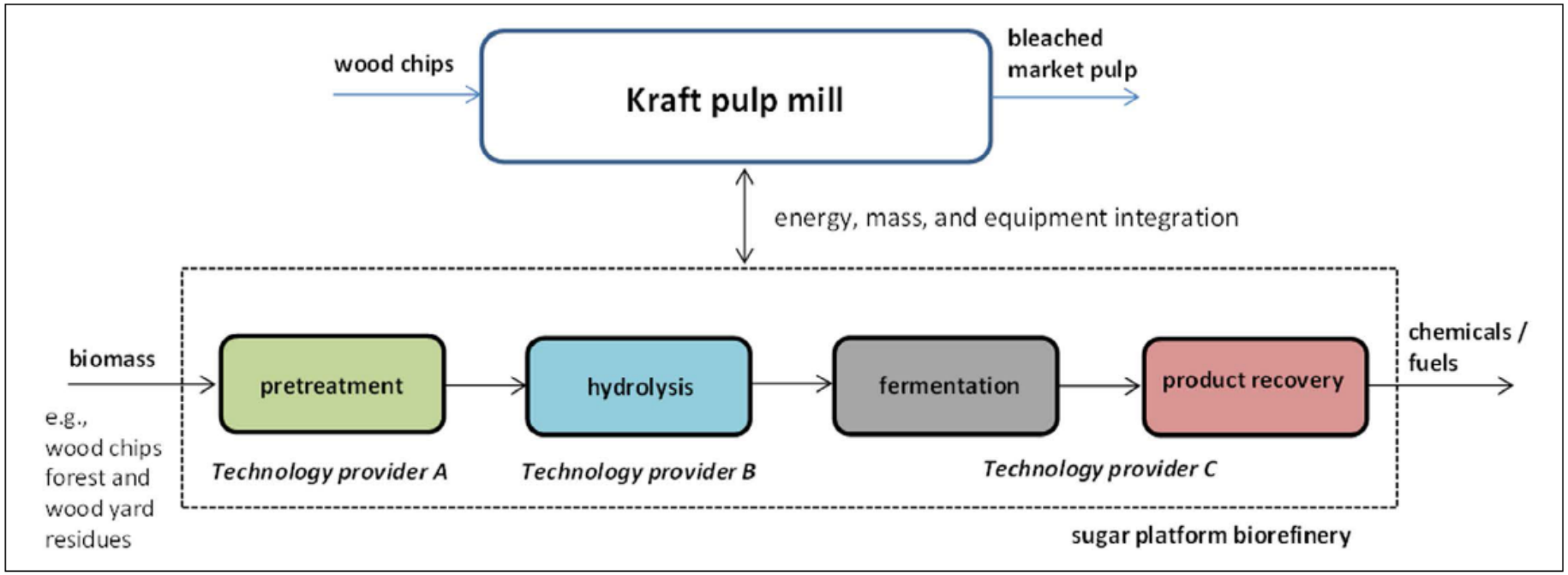


Fig. 2 - **Sugar platform biorefinery integrated with a Kraft pulp mill.**

Mariano (2015), J-FOR v.4(5):12-19

Challenges for pulp companies seeking transformation to biorefineries

- **Limited know-how** in many of the pertinent technical and business areas

- Transformation to the biorefinery involves expanding the focus of companies to **additional product portfolios** by implementing emerging technologies

- From the investor's perspective, decision-making about **product-process combinations that lead to sustainable business models and good economic returns is not obvious**

- Implementing a successful biorefinery strategy leading to transformation implies **identifying and addressing a combination of business, financial, and technology risks**

- **Intrinsic optimism of technology developers** + the need to attract interest from financiers and customers => can lead to **over-promised technical metrics and underestimated timelines and costs**

Effect of Technology and Market risk on cost of capital

Technology risk has been considered as the major **contributor to increasing the cost of capital** for biomass-derived bio-fuels projects

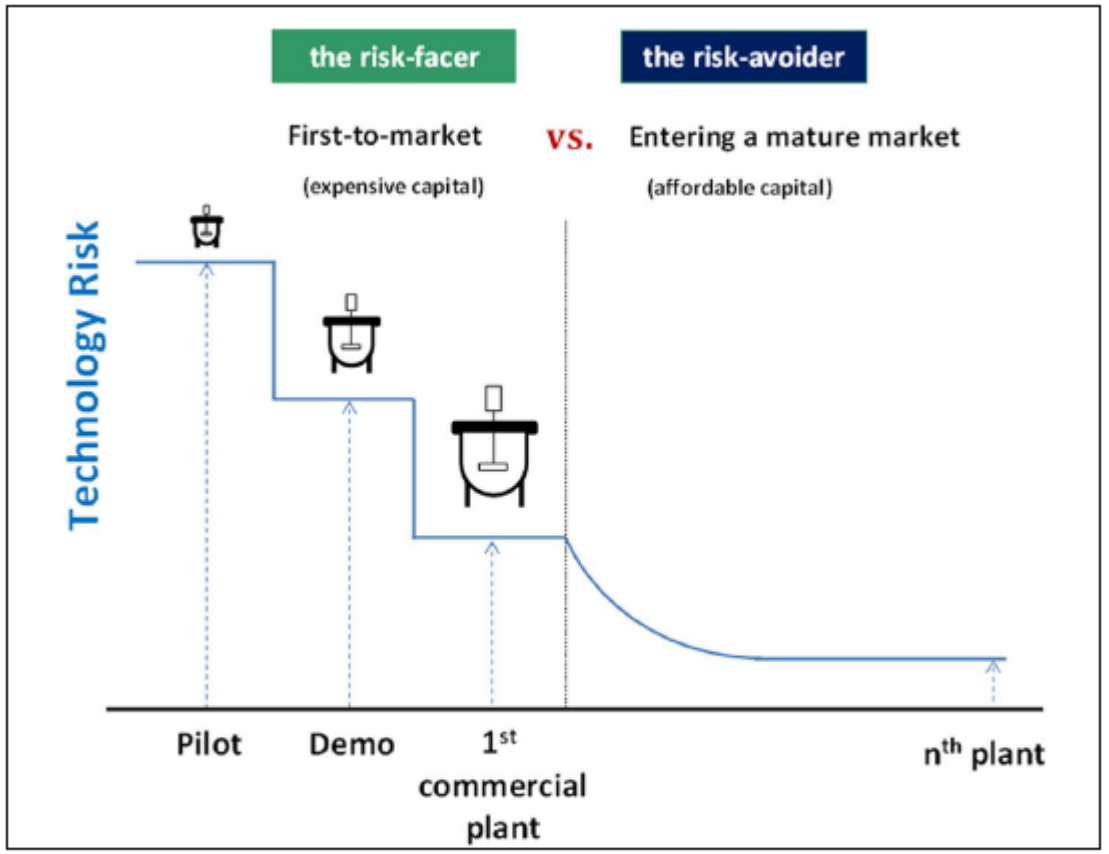


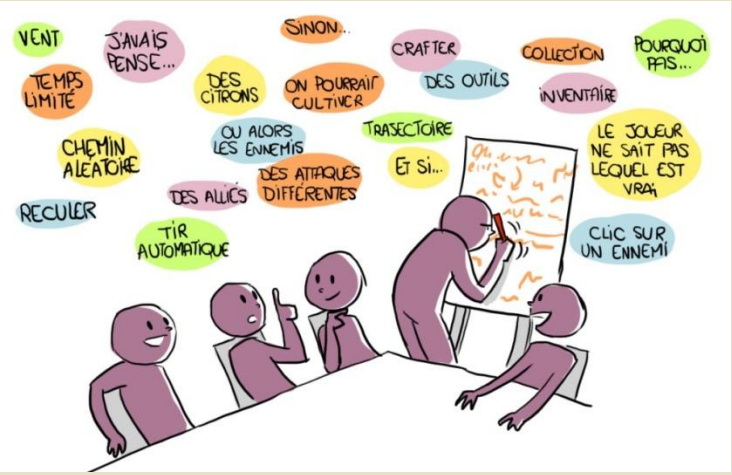
Fig. 1 - Trade-off between (i) evolution of technology risk and cost of capital through development stages and deployment of commercial plants and (ii) market risk.

Mariano (2015), J-FOR v.4(5):12-19

Developing the critical view in a pulp company

- **Creation of a tool that enables the systematic evaluation of technical risks related to sugar platform technologies in an early-stage design context**

- **List of potential technical risks generated by the Biorefinery team (4 chemical engineers) of a major Brazilian market pulp company**



List of technology risks put together by the biorefinery team

TABLE 1 *Potential technology risks related to sugar platform biorefinery projects in general and their integration with pulp mills.*

Risk category	Risk criterion
Scale-up	1. Difference between the current capacity of the technology and the capacity planned by the provider for the first commercial plant 2. The capacity planned by your company is significantly greater than the capacity planned by the provider for the first commercial plant 3. Level of integration of unit operations at the current level of development (i.e., the degree of fidelity to the first commercial plant) 4. Total effective operating hours of the technology up to the current level of development 5. Level of design (conceptual, basic, detailed) reached by the provider regarding the first commercial plant 6. Number of unit operations in the process 7. Ratio (number of new technologies) / (off-the-shelf technologies), taking into account all steps of the process
Integration	8. Flow of liquid waste compared to the capacity of the wastewater treatment unit of the host pulp mill 9. Amount of solid residues (e.g., gypsum generated by an acid pre-treatment technology) 10. Principal type of energy consumed by the process (steam or electricity) 11. Steam and power consumption of the technology compared to the current consumption of the host pulp mill 12. Water consumption of the process 13. Integration with any piece of equipment of the host pulp mill (e.g., sending a liquid waste stream with organic matter to the evaporation and recovery system of the mill) 14. Impact on the total CO_2 emissions of the site
Technology	15. Types of biomass already tested by the technology provider 16. Level and number of specifications regarding biomass feed conditions (e.g., moisture, particle size) 17. Combination of technologies from different providers (e.g., pre-treatment from Company X / fermentation from Company Y) 18. Presence of a catalytic chemical reaction step in the process 19. Pre-treatment operated at high pressure (>30 bar) 20. The technology runs with feedstock-specific enzymes or microorganisms 21. Use of advanced fermentation technologies (e.g., intensified technologies with product recovery integrated with the fermenter) 22. Fermentation runs in continuous mode (unlike the traditional batch-wise operation) 23. Use of genetically modified microorganisms (GMOs) for fermentation 24. The microorganism used in the fermentation step is a bacterium 25. Intensified processes (e.g., hydrolysis and fermentation combined in the same unit operation) 26. Level of sterility demanded by the equipment and the sugar solution to the fermentation step 27. Use of recovery and purification technologies with high energy efficiency (replacing traditional distillation)

A second opinion…screening the most relevant risk criteria

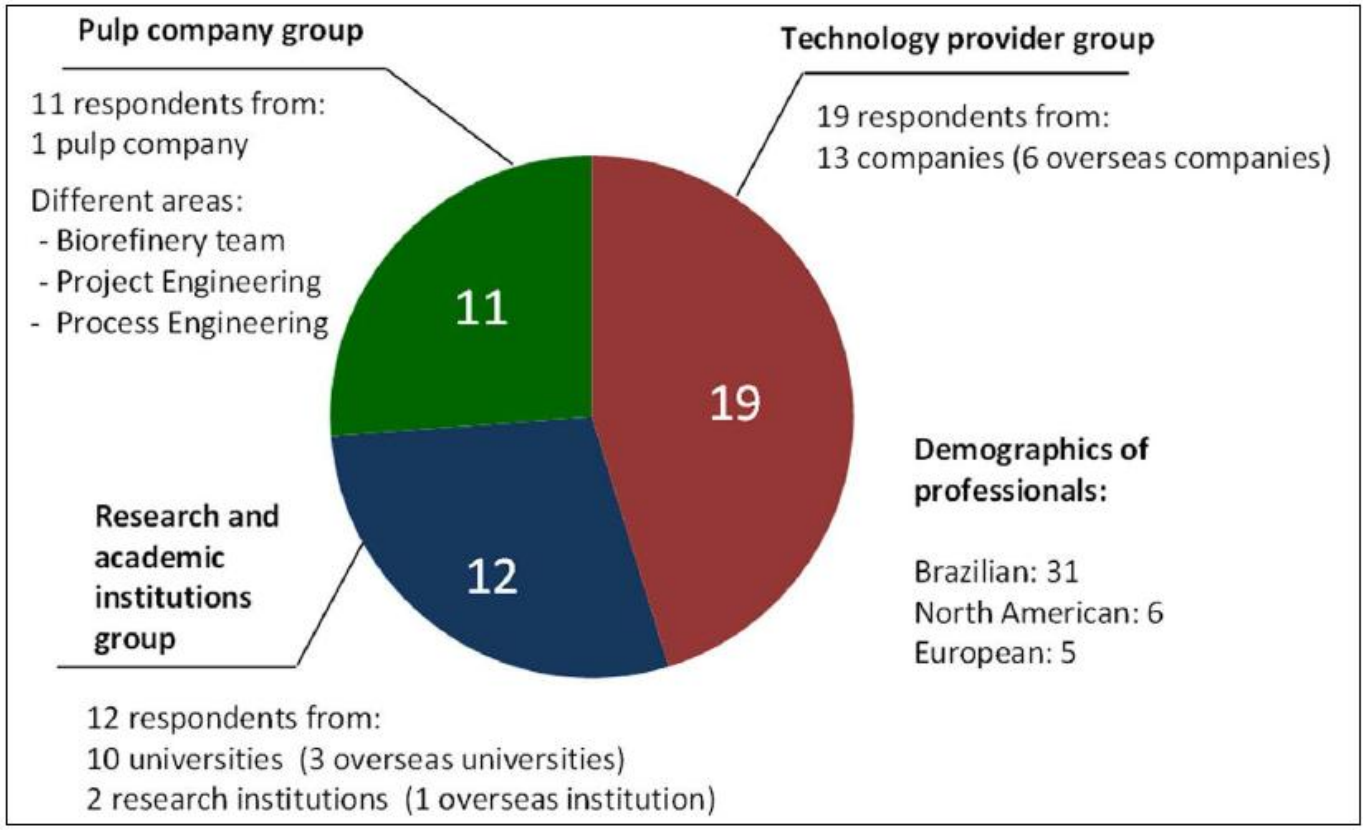


Fig. 3 - Breakdown of the 42 professionals who assessed the risk criteria.

A second opinion…screening the most relevant risk criteria

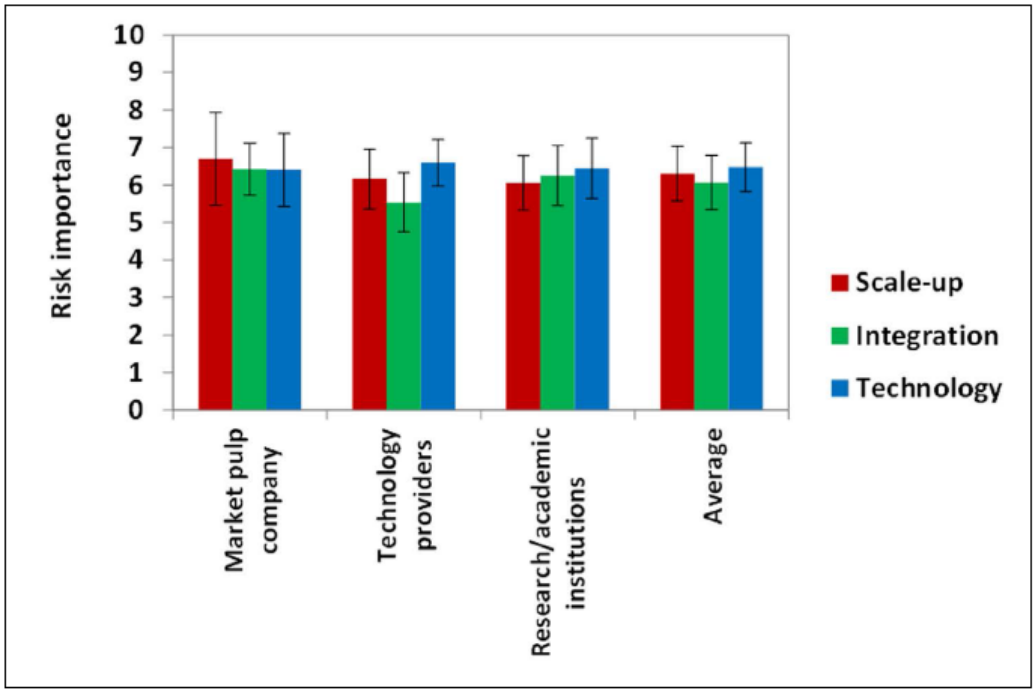


Fig. 4 - Opinions (scores from 1 to 10) of the three groups of professionals regarding the importance of each risk category.

There was a good agreement on:

(i) the relative importance of the risk categories

(ii) the ranking of the most important set of criteria

A marked difference between the opinions of Brazilians and non-Brazilians concerning the risk related to (iii) genetically modified organisms

(ii) Ranking of the most important set of criteria

The three most important criteria were all t**echnology-related**, reflecting concerns about **process flexibility**, **microorganism performance**, and **microbiological contamination issues**.

TABLE 2 *Selected technology risk criteria according to surveyed professionals from a pulp mill, technology companies, and research and academic institutions.*

Risk category	Risk criterion	Score			
		T	I	P	Average
Scale-up	The ratio (number of new technologies) / (off-the-shelf technologies), taking into account all steps of the process	6.96	6.58	7.00	6.85
	Level of integration of the unit operations at the current level of development (i.e., the degree of fidelity to the first commercial plant)	6.78	6.75	6.82	6.78
	Difference between the current capacity of the technology and the capacity planned by the provider for the first commercial plant	6.11	5.58	8.20	6.63
	Average	**6.61**	**6.31**	**7.34**	**6.75**
Integration	Integration with any piece of equipment in the host pulp mill (e.g., sending a liquid waste stream with organic matter to the mill evaporation and recovery system)	6.68	6.83	7.55	7.02
	Steam and power consumption of the technology compared to the current consumption of the host pulp mill	5.89	7.58	6.73	6.74
	Water consumption of the process	6.32	6.67	7.00	6.66
	Average	**6.30**	**7.03**	**7.09**	**6.81**
Technology	Use of genetically modified microorganisms (GMOs) for fermentation	6.44	7.55	7.88	7.29
	The technology runs with feedstock-specific enzymes or microorganisms	7.28	7.00	7.50	7.26
	Level of sterility demanded by the equipment and the sugar solution to the fermentation step	7.67	7.08	7.00	7.25
	Average	**7.13**	**7.21**	**7.46**	**7.27[a]**

T: technology providers; I: Research and academic institutions; P: pulp mill
[a] Statistically different (at $p<0.05$) from 6.75 (Scale-up) and from 6.81 (Integration)

Take-home massages

For technology developers:

- Do not take for granted that standard unit operations will work fine integrated to your technology
- If your business plan is focused on having your technology as bolt-on facilities annexed to existing plants, consider integration risks as an effective guidance to technology development

For technology buyers:

- **Always be critical:** on the technology itself, including proposed risk mitigation strategies, lab/pilot tests, and economics
- **You know well your plant:** estimate hidden costs needed to integrate the biorefinery to your site and add them to the economic model provided by the technology developer
- **Make informed decisions:** systematic methodologies and tools designed to evaluate technology risk of potential biorefinery candidates can contribute to the decision-making process

For more details…

DUE DILIGENCE FOR SUGAR PLATFORM BIOREFINERY PROJECTS: TECHNOLOGY RISK

ADRIANO P. MARIANO

ABSTRACT

This work presents a comprehensive list of potential technology risks suitable for conducting due diligence for sugar platform biorefinery projects. The list was elaborated by the biorefinery team of a Brazilian market pulp company, and professionals from three different groups (technology providers, research and academic institutions, and pulp manufacturers) gave their opinions on the relative importance of each risk criterion. The survey demonstrated that the 42 professionals were in good agreement on which technology risks should be given greatest importance when assessing promising sugar platform bio-refineries to be retrofitted to Kraft pulp mills. The importance of the risks associated with general scale-up and integration of the technology with a pulp mill and the particular risks associated with the sugar platform were perceived similarly across the surveyed groups. The respondents expressed major concerns about the performance of genetically modified microorganisms at scale, potential hindrances due to microbiological contamination, and technologies with limited feedstock flexibility. For pulp and paper companies evaluating the sugar platform, the list of technology risks is recommended as part of systematic risk assessment activities during the early-stage design phase and also for use as a questionnaire to be administered to companies offering technological solutions for production of lignocellulosic sugars as well as technologies for their conversion into bio-fuels and chemicals.

J-FOR | Journal of Science & Technology for Forest Products and Processes: VOL.4, NO.5

adrianomariano@feq.unicamp.br