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CURSO CYTED
VALORIZACIÓN de RESIDUOS, BIOECONOMÍA y ECONOMÍA CIRCULAR

Integración de procesos. Conceptos generales.

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Industrial Symbiosis

The generally accepted definition of industrial symbiosis is that there are ample economic, environmental and social benefits originating from material exchanges and other shared resource flows, both between and within industries

Industrial ecology/ Industrial symbiosis (IE/IS)
Circular economy (CE)
Process integration (PI)
Eco-industrial parks (EIP)

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Historical Process Integration

HAMAGUCHI, M.; PARK, S.W. (2009) *Process Integration Methods in Pulp and Paper Industry for Water Usage Reduction*. 10th International Symposium on Process Systems Engineering - PSE2009.

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Superstructure

Representation of a Superstructure STN - State-task network (Chen and Grossman, 2017)

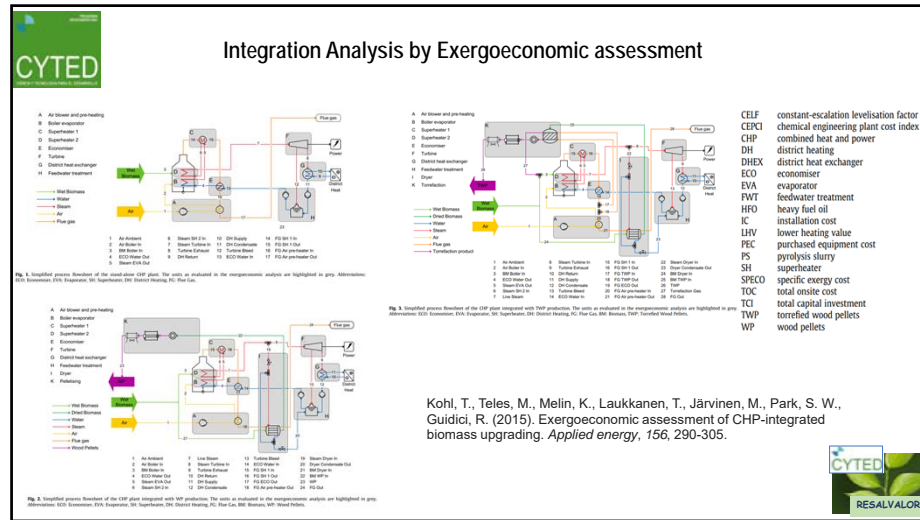
Representation of a Superstructure SEN - State-equipment network (Chen and Grossman, 2017)

Representation of a Superstructure for only one distillation column (Viswanathan and Grossman, 1993)

VIEIRA, A.M.N.; RAMOS, M.; PROJETO RIGOROSO DA COLUNA DE DESTILAÇÃO POR ASPEN PLUS COM DIFERENCIAL EVOLUCIONÁRIO. Licencieate Thesis. USP. PARK, S.W. (orientador)

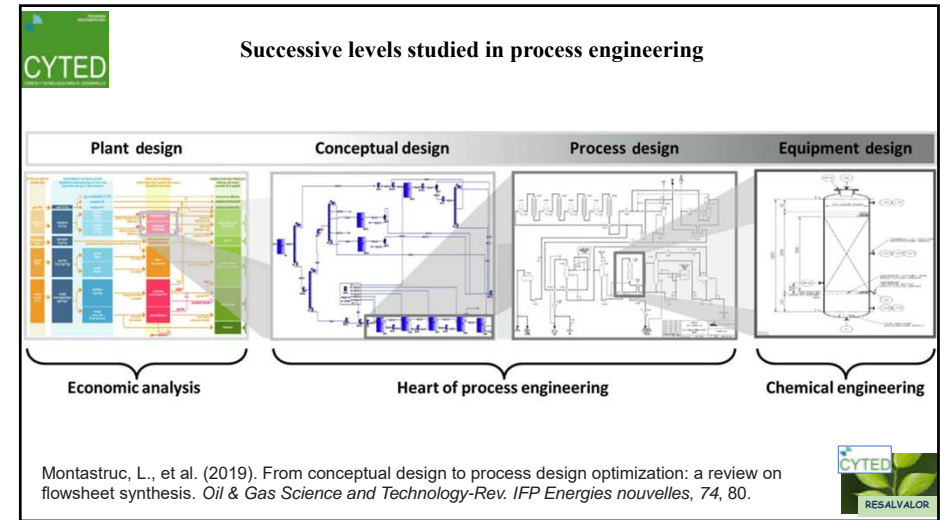
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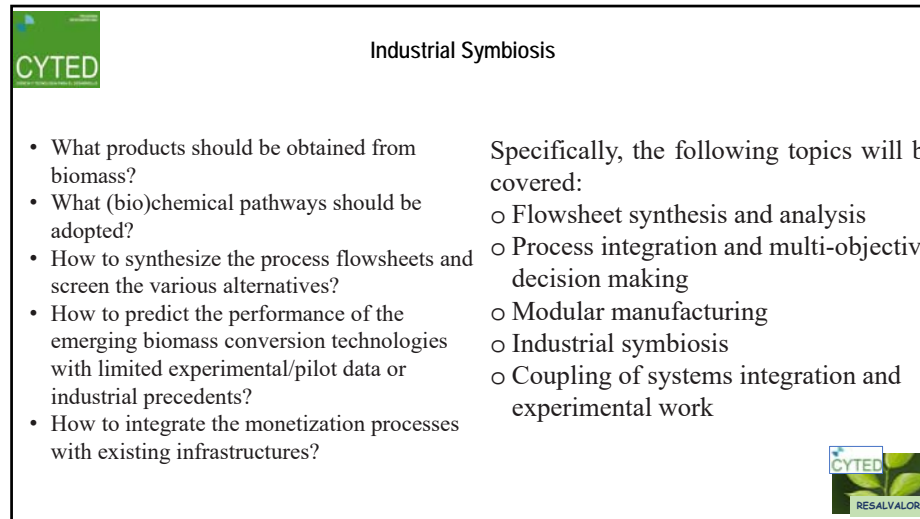


Kohl, T., Teles, M., Melin, K., Laukkanen, T., Järvinen, M., Park, S. W., Guidici, R. (2015). Exergoeconomic assessment of CHP-integrated biomass upgrading. *Applied energy*, 156, 290-305.

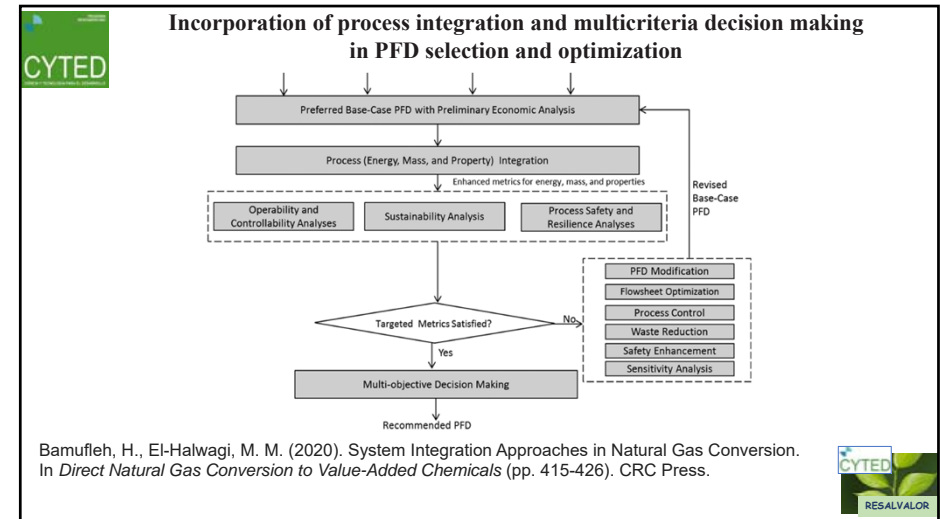
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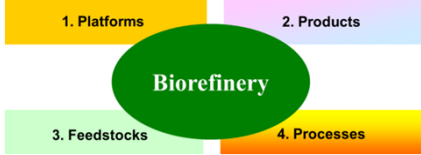
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The role of process flexibility in the Bioeconomy Integration



- ✓ Multi-feedstock
- ✓ Multi-products
- ✓ Integrating Several (bio) Chemical Process
- ✓ Integration of Energy and Water

What are Platform, Products, Feedstocks and Processes? To clarify, please see Cherubini, F., Jungmeier, G., Wellisch, M., Willke, T., Skiadas, I., Van Ree, R., de Jong, E. (2009). Toward a common classification approach for biorefinery systems. *Biofuels, Bioproducts and Biorefining*, 3(5), 534-546.

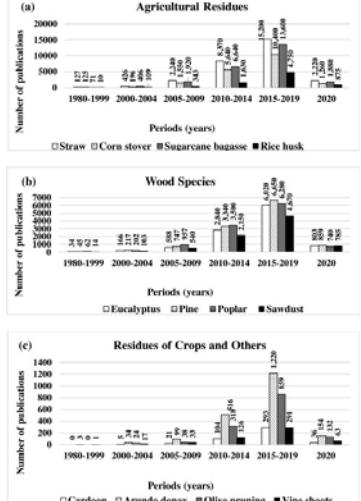
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Multi-Feedstock

Number of research papers published related with the valorisation of LCB (by five years periods)



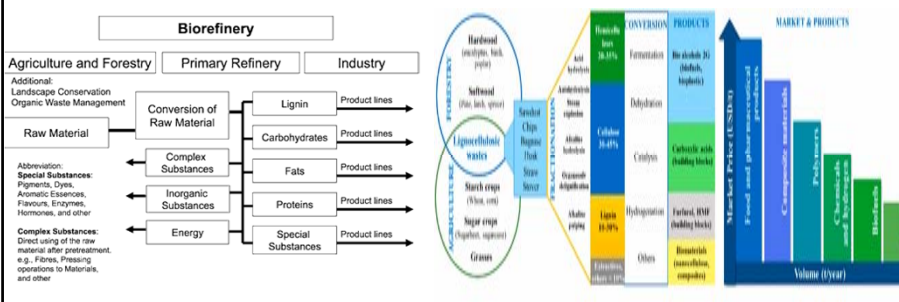
García-Ochoa, F., Vergara, P., Wojtusik, M., Gutiérrez, S., Santos, V. E., Ladero, M., Villar, J. C. (2021). Multi-feedstock lignocellulosic biorefineries based on biological processes: An overview. *Industrial Crops and Products*, 172, 114062.

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Multi-product



Kamm, B., Kamm, M. (2007). Biorefineries—multi product processes. *White Biotechnology*, 175-204.

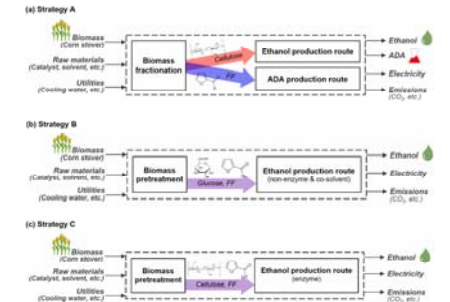
Clauser, N. M., Felissia, F. E., Area, M. C., Vallejos, M. E. (2021). A framework for the design and analysis of integrated multi-product biorefineries from agricultural and forestry wastes. *Renewable and Sustainable Energy Reviews*, 139, 110687.

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11

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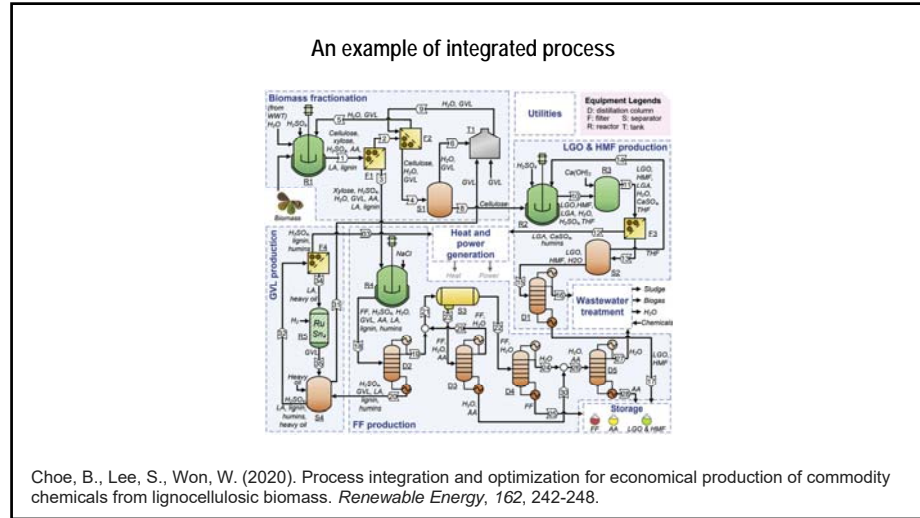
An example of integrated process



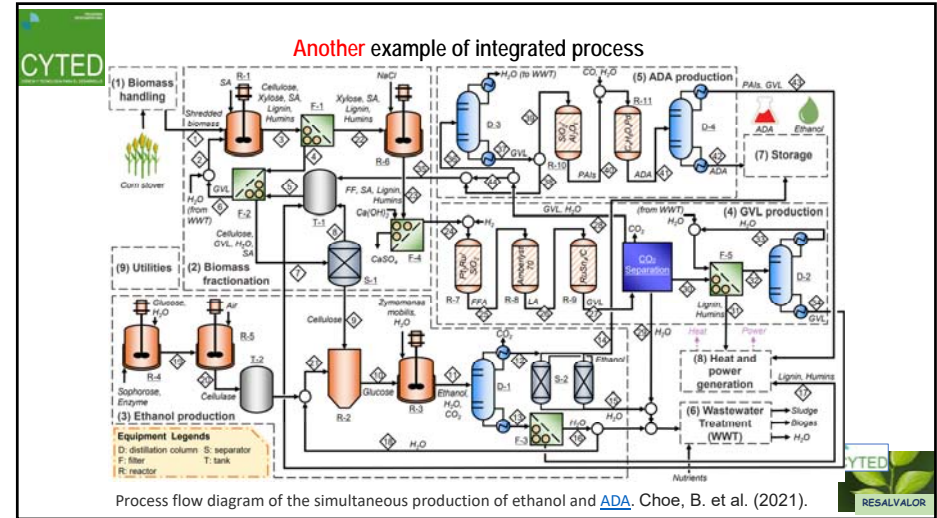
Choe, B., Lee, S., Lee, H., Lee, J., Lim, H., Won, W. (2021). Integrated strategy for coproducing bioethanol and adipic acid from lignocellulosic biomass. *Journal of Cleaner Production*, 127849.

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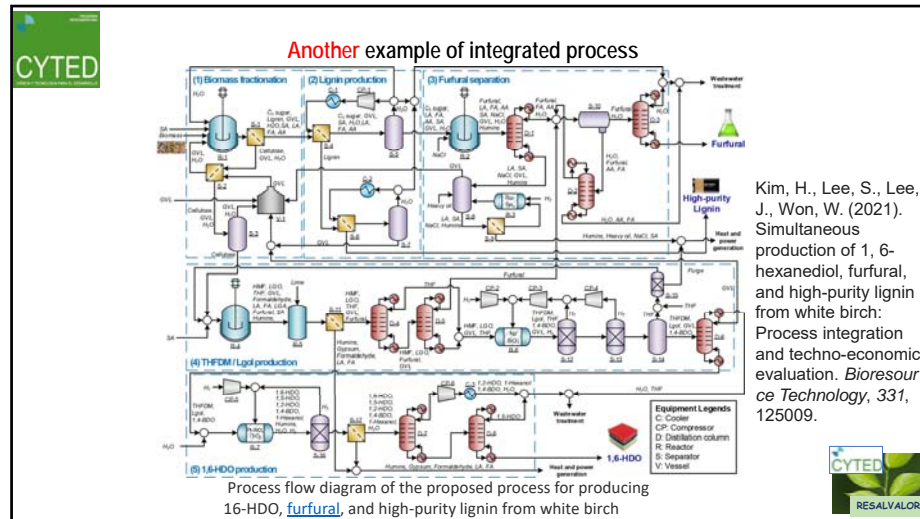
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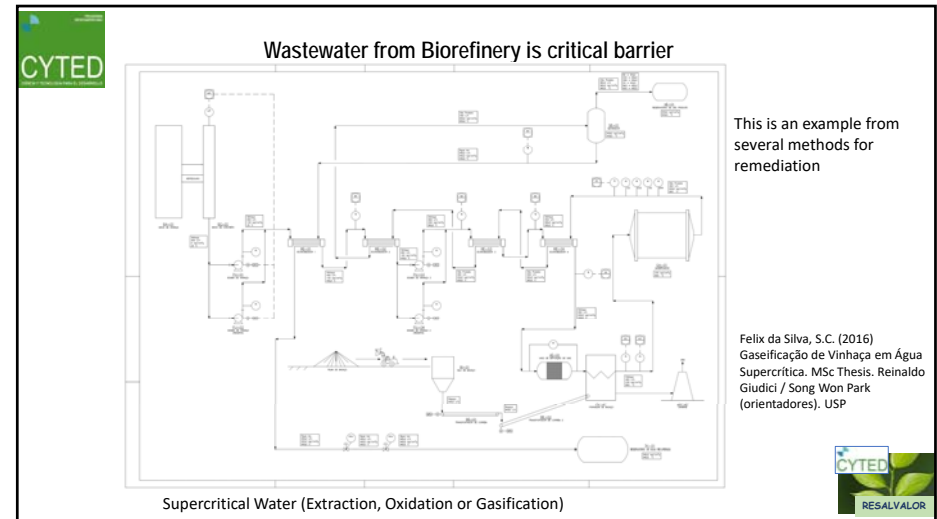
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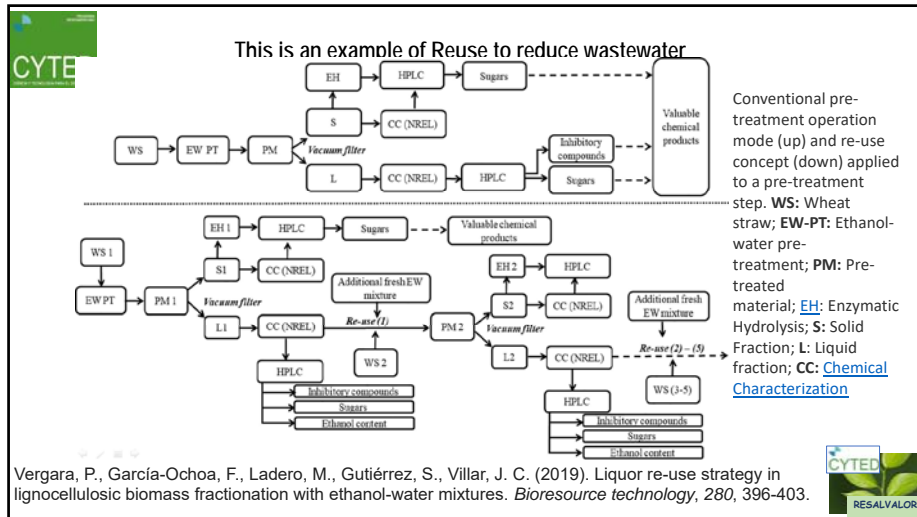
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15



16



17

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Remarks

To work with process integration, before any method application, it is worthy to understand the basic (fundamental) experience of Process Design.

- Killcross, Martin - Chemical and process plant commissioning handbook -2nd Edition (2021)
- Towler, Gavin_ Sinnott, Ray K. - Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design-Elsevier (2021)
- Richard Turton et al. - Analysis Synthesis and Design of Chemical Processes-Pearson (2018)
- Killcross, Martin - Chemical and process plant commissioning handbook -2nd Edition (2021)
- Leland Blank, Anthony Tarquin - Engineering Economy-McGraw-Hill (2018)
- William G. Sullivan, Elin M. Wicks, C. Patrick Koelling - Engineering Economy, Global Edition, 17th Edition-Pearson (2019)
- Main, S., Dalvi, V. H., Shashtri, Y., Odaneth, A. A. (2021) LCA and TEA for Biomass Conversion Technology. In *Biomass for Bioenergy and Biomaterials* (pp. 65-92). CRC Press.

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18

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Remarks

All computer aided design tools must be used with some discretion and engineering judgment on the part of the designer. This judgment mainly comes with experience. *The art and practice of design cannot be learned from books. The intuition and judgment necessary to apply theory to practice will come only from practical experience.*

Gavin Towler

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19

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Gracias por la atención

Jueves 07 octubre

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20