Natural Resources Canada | Ressources naturelles Canada

ADVANCED BIOREFINERY PROCESSES

I-BIOREF SOFTWARE

Canada

DECISION SUPPORT TOOL FOR EVALUATING BIOECONOMY TRANSFORMATION STRATEGIES

I-BIOREF is a state-of-the-art decision support tool to create, model and analyze industrial biorefinery and bioeconomy projects. In a stepwise manner, the tool enables technical, economic, environmental and socio-economic performances of these projects to be quantified.

I-BIOREF evaluates the benefits associated with the most advanced biorefinery processes, and helps the user identifying viable solutions in various implementation contexts.

I-BIOREF combines a flexible software architecture, over 50 multidisciplinary decision metrics, location-specific project assessment and multiple databases to identify effective and sustainable biorefinery solutions for the production of multiple bio-based products such as bioenergy, renewable fuels, chemicals and materials.

CHALLENGES FOR THE TRANSFORMATION **OF INDUSTRIES TOWARDS BIOECONOMY**

Conflicting pathways and strategies that evolve within an uncertain business environment can make decision-making complex, hindering the integration of a low-carbon economy and bioeconomy for a sustainable industry transformation. Therefore, a new paradigm is needed to ensure coherence and flexibility along the decision-making chain.

Although implementing new strategies implies taking some risks, bioeconomy stakeholders are not necessarily risk prone. Rather, they tend to adopt hybrid scenario analysis approaches that combine prospective and ad hoc methods to deal with the uncertainties associated with technical, economic and policy risks, as well as the social acceptability of bioeconomy projects.

The integration of biorefinery technologies into existing and new facilities raises critical questions:

BENEFITS

What are the benefits of integrating biorefinery technologies into a given facility, and which best practices may be established?

STRATEGIES

Which implementation strategies are economically and environmentally viable in the short, medium, and long terms?

POLICY

How do policy measures and instruments influence the definition and/or decision for the biorefinery strategy?

AN INTEGRATED BIOREFINERY DECISION **SUPPORT PLATFORM**

The main benefit for I-BIOREF users is the ability to define and model state-of-the-art biorefinery projects in a multitude of contexts, and to evaluate them using a multidisciplinary set of decision metrics. This can be done while running different future scenarios and graphically representing results, all within a **single software platform**.

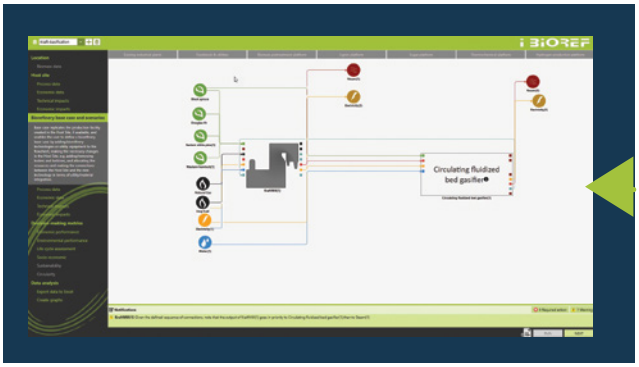
A biorefinery is widely defined as an integrated industrial complex utilizing various biomass resources to produce multiple bioproducts, including bioenergy, renewable fuels, biochemicals and biomaterials. As a decision support tool aimed at facilitating the evaluation of biorefinery projects, I-BIOREF allows users to easily model and assess biorefinery pathways, including the most advanced and technologically mature solutions.

I-BIOREF features a user-friendly graphical interface and a comprehensive library of well-established biorefinery technologies, making possible the modelling of a wide range of bioeconomy projects, all while assessing their performance within scenarios where multiple project parameters can be changed simultaneously. That way, I-BIOREF users have the flexibility to model the integration of small biorefinery units into existing industrial plants, as straightforwardly as they could represent large-scale bio-hubs, including multiple technology combinations into a newly developed site.

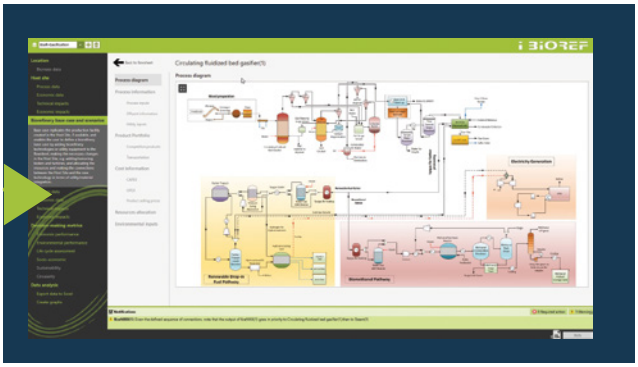
In addition, I-BIOREF allows users to perform multidisciplinary comparative analyses of biorefinery projects by featuring decision metrics that are representative of the main uncertainty issues faced by bioeconomy stakeholders. The current set of metrics covers technical, economic, environmental, and socio-economic perspectives. Metrics representative of circularity and sustainability perspectives are also being developed.

BIOREFINERY TECHNOLOGIES **EMBEDDED IN I-BIOREF**

In addition to models of representative industrial plants (e.g. sawmills, kraft pulping and thermomechanical pulping mills), I-BIOREF provides access to the main modelling parameters for each step of the biomass valorization process, ranging from the preprocessing and pretreatment of various biomass resources to its conversion into intermediate or final bioproducts.



Biorefinery technology integrated into kraft pulp mill



Biorefinery technology process flow diagram

TECHNOLOGY PLATFORMS IN I-BIOREF:

- Chemical-free (e.g. liquid hot water extraction) and chemical-based (e.g. Organosolv, dilute acid hydrolysis) biomass pretreatment processes
- Lignin extraction and valorization technologies (e.g. LignoBoost®, LignoForce System®, Sequential Liquid-Lignin Recovery and Purification [SLRP™], and electrochemical lignin recovery)
- A sugar platform including processes for the conversion of sugar-rich streams resulting from biomass preprocessing units into more valuable products such as furfural or butanol
- Thermochemical technology platforms including thermal and catalytic fast pyrolysis, fixed and circulating fluidized bed gasification configurations, and hydrothermal liquefaction
- A hydrogen platform including autothermal reforming of methane, steam methane reforming, alkaline electrolysis, polymer electrolyte membrane electrolysis, and pyrolysis of methane

Each biorefinery technology can be easily connected to different feedstock (biomass, biogas, carbon dioxide, hydrogen, fossil-based natural gas, natural renewable gas and syngas), utilities (electricity, various fuel sources, steam, water), and utility systems (anaerobic digestion, power boiler and wastewater treatment) required for its operation.

ANALYSIS
FEATURES

Each industrial plant or biorefinery technology model is supported by detailed mass and energy balances and key process characteristics, including electricity, steam, water, biomass, fuel, chemicals, and effluents. Process flow diagrams of the selected industrial process are also provided to visualize the main unit operations involved.

To ensure valid data communication, an automatic control functionality is incorporated to perform diagnostics for data quality and specification. Such a functionality provides both warnings and required actions to guide users in creating a biorefinery project in a step-by-step manner.

Present and ex-ante scenario analyses driven by changes in controlled technical and economic variables are also some of the benefits of the I-BIOREF decision support tool.

I-BIOREF provides a complete evaluation of technical, economic, environmental, life cycle, socio-economic, sustainability, and circularity impacts when developing a biorefinery project.

Scenario analysis

Multi-criteria decision-making metrics

SOFTWARE **CAPABILITIES**

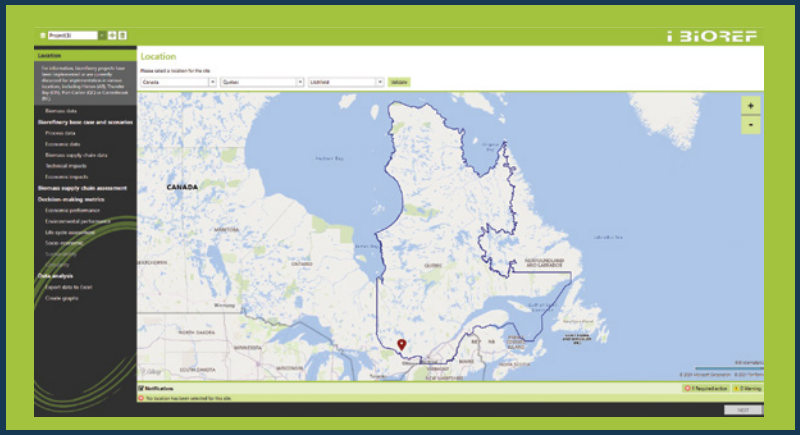
FOR SIMULATION OF BIOREFINERY VALUE CHAIN OPERATIONS, I-BIOREF INCLUDES:

- A map-based functionality to help both experts and non-experts in the fields of biorefinery and bioeconomy to locate projects and have access to local census data for socio-economic assessment.
- Biomass procurement and logistics planning that minimizes the costs of acquiring, storing, chipping and transportation of forest biomass across the supply chain. This model considers different biomass suppliers and buyers operating in the territory where the biorefinery project is or will be implemented.
- Process flow diagrams representing the multiple process units within each biorefinery technology and mill.
- Chemical, energy and mass balances with existing recycling loops and operational constraints.
- Breakdown of equipment involved in each biorefinery technology, such as but not limited to feedstock preparation (conveyor screening, mechanical disintegrator, dryer), chemical and biochemical reactors, membrane and distillation systems, pumps, compressors, storage tanks, filter presses, electrolysis units, gas-fired systems, boilers, heat exchangers, etc.
- Process information (inputs, effluents, and utility), product portfolio (competitive products, transportation), cost information (product selling prices, operating and capital expenditure), resource allocation, environmental inputs, etc.
- Complex integrated biorefinery technology configurations and interconnected biopark systems can be modeled and evaluated from techno-economic, socio-economic, life cycle and environmental perspectives. These interconnections allow for the assessment of biopark system sustainability as well as the analysis of scenarios to optimize existing assets.

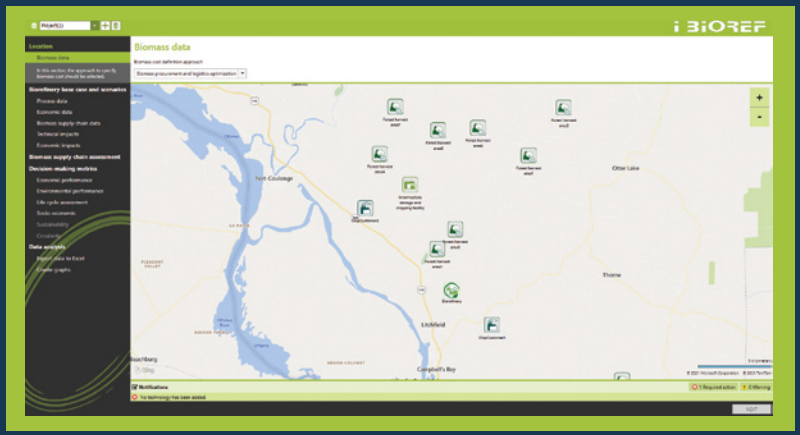
Multidisciplinary evaluation of decision-making metrics, including economic (profitability, robustness, capital efficiency, business value proposition), environmental (stress on environment, GHG emissions, carbon sequestration), life-cycle assessment (human health, ecosystem quality, climate change, resources, water scarcity footprint) and socio-economic factors (direct and total job creation, project attractiveness to labour forces, likelihood of local support for the biorefinery project, partnerships with Indigenous communities).

The various results and metrics calculated in I-BIOREF for all scenarios can be presented side by side in convenient and dynamic tables. I-BIOREF also has a graph wizard to create and edit 2D graphs (e.g. line, bar, and pie charts) for easier comparison of different scenarios and to run sensitivity analyses of key parameters.

Export data to Excel feature that allows users to further analyze the various results and expand the calculations to fulfill specific needs that are not represented in I-BIOREF.



Mapping the location of biorefinery projects



Biomass procurement and logistics planning model

Wizard to create graphs

COGEN – For maximizing efficiency and revenues from cogeneration systems
INTEGRATION – For optimizing heat recovery in plants
EXPLORE – For improving process operation, using the power of advanced data analysis
I-BIOREF – For evaluating the economic viability as well as socio-economic and environmental impacts of biorefinery technologies

For more information, please visit our website or contact us: www.nrcan.gc.ca | 1-450-652-4621
Email: i-bioref@nrcan-rncan.gc.ca
Cat.: M154-144/2021E-PDF | ISBN: 978-0-660-39771-9