POLYTECHNIQUE MONTRÉAL
LE GÉNIE EN PREMIÈRE CLASSE

INSTITUT DE L'ÉNERGIE TROTTIER

E²D²BF

IMPROVING the THERMAL ENERGY EFFICIENCY of the PULP & PAPER INDUSTRY

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Highlights

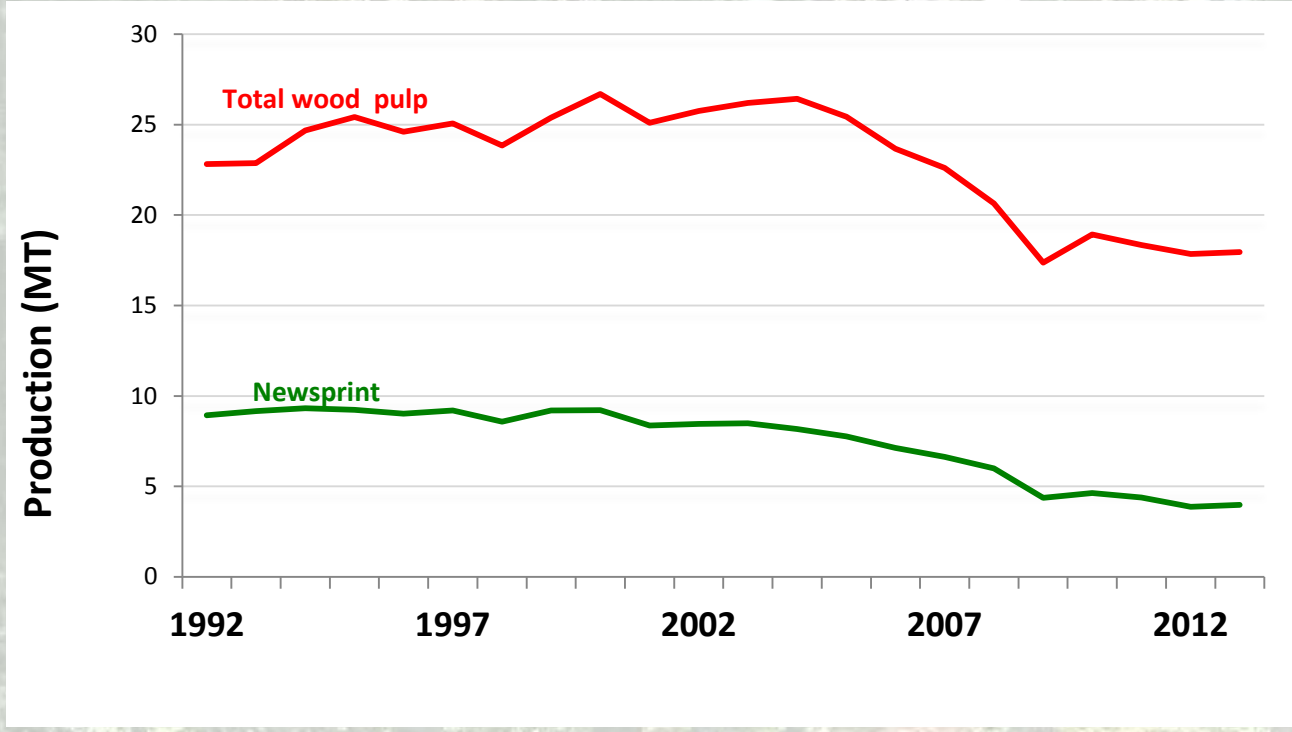
Part I: **CONTEXT & JUSTIFICATION**

- The P&P Industry in difficult times
- The forest biomass, a feedstock for new products
- The industry is diversifying its products portfolio

Part II: **THE METHODOLOGY**

- The energy challenge and its solution
- A novel methodology tailored to P&P processes
- Results and further developments

An Industry in precarious Times



Forest rotation time

Canada 50-80 yrs

Tropical Forest 15-25 yrs

- The demand for commodity products (newsprint, printing paper) is declining and the trend will probably continue
- New and large pulp making facilities are coming on line in tropical regions with fast growing forest and low labor costs

The Forest, an Abundant Source of Renewable Biomass

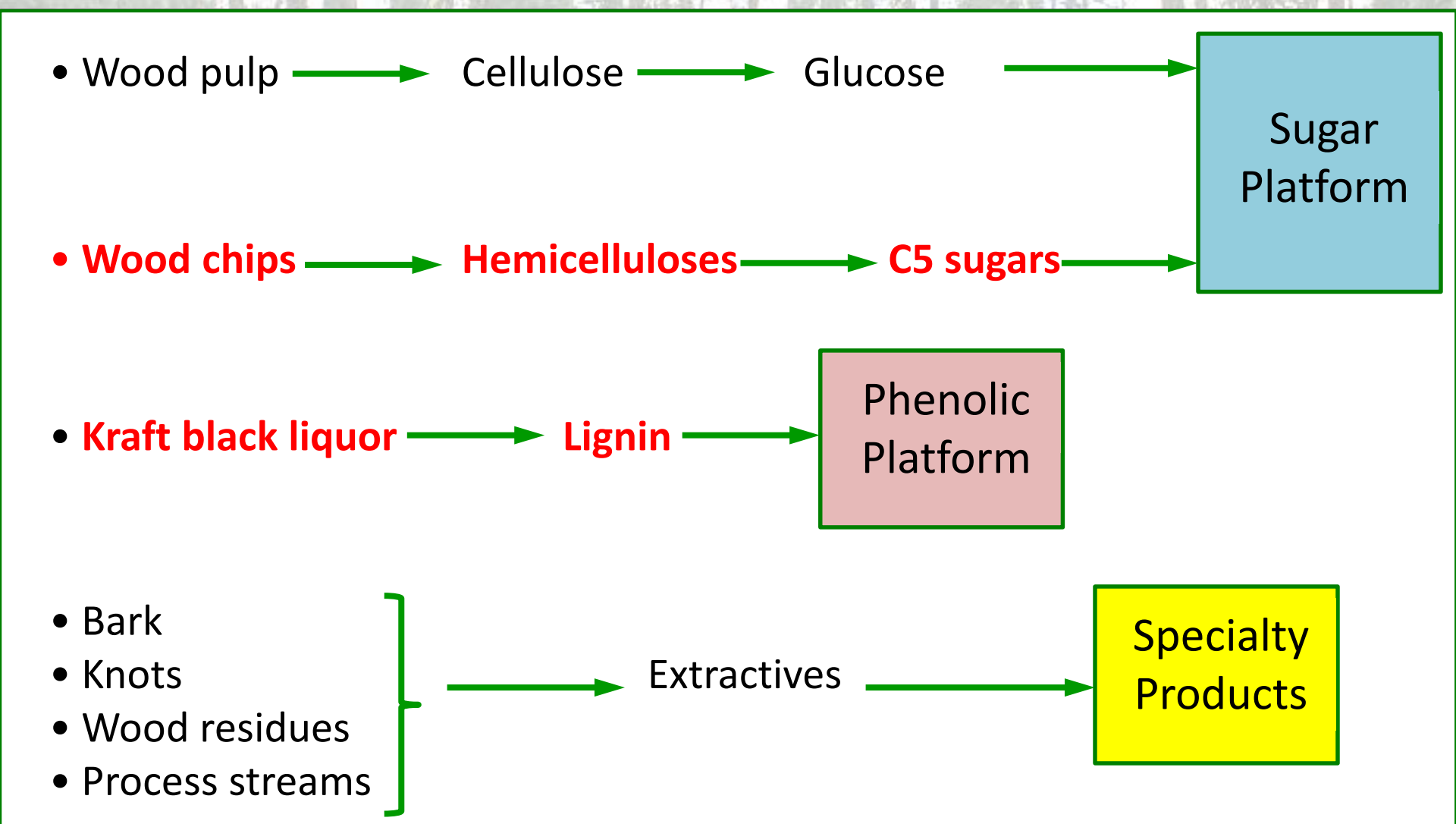
- If managed and exploited responsibly, the forest biomass has a net zero carbon footprint

  CO_2 absorbed by growing trees ≥ CO_2 released by conversion / utilization

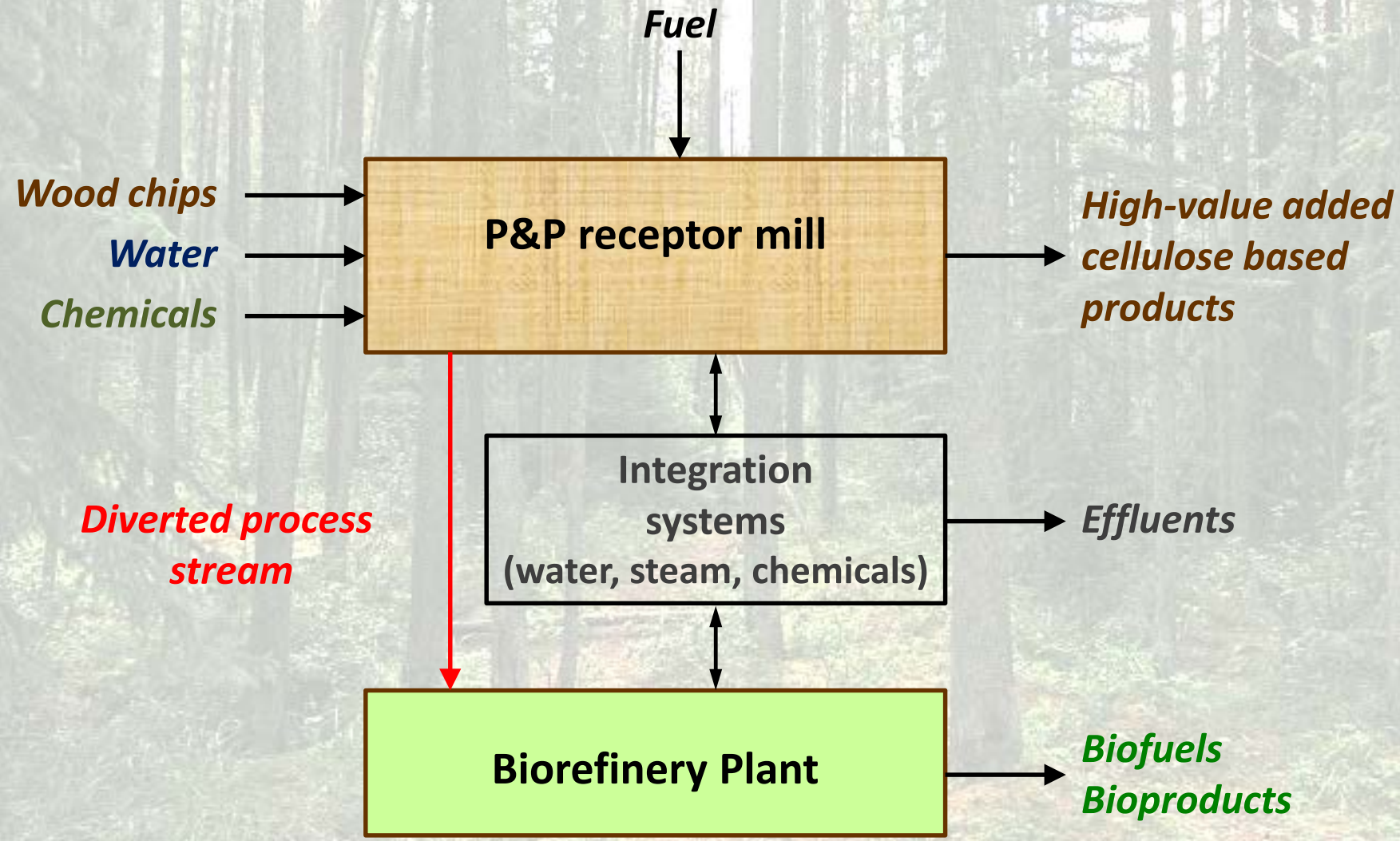
- Forest do not compete with food crops for arable land; it can grow on marginal land
- The forestry and P&P sectors have solid, well implemented infrastructures and a trained and competent workforce

Existing paper mills can process and partition the forest biomass to manufacture new products

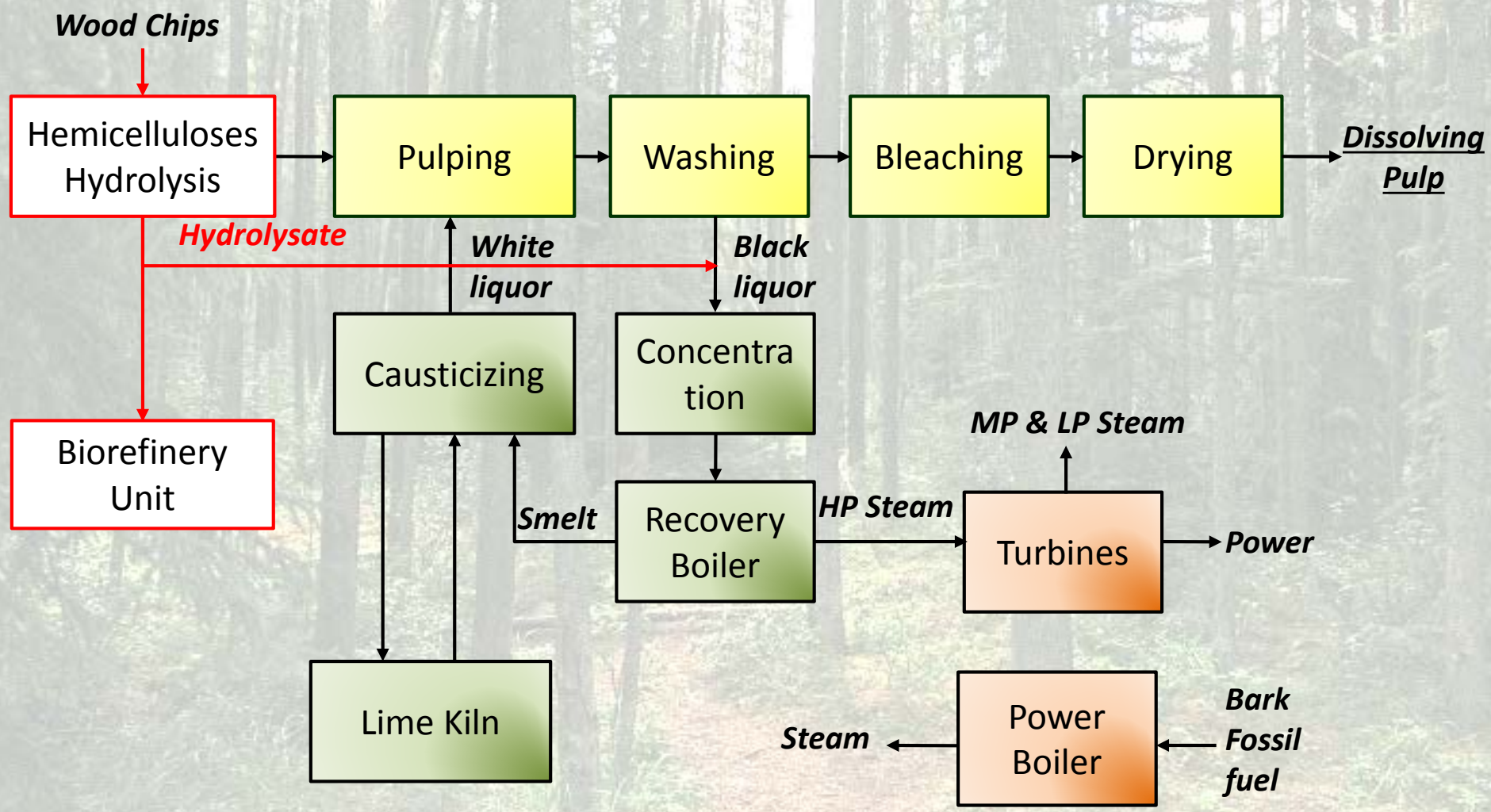
From Wood Components to Bioproducts



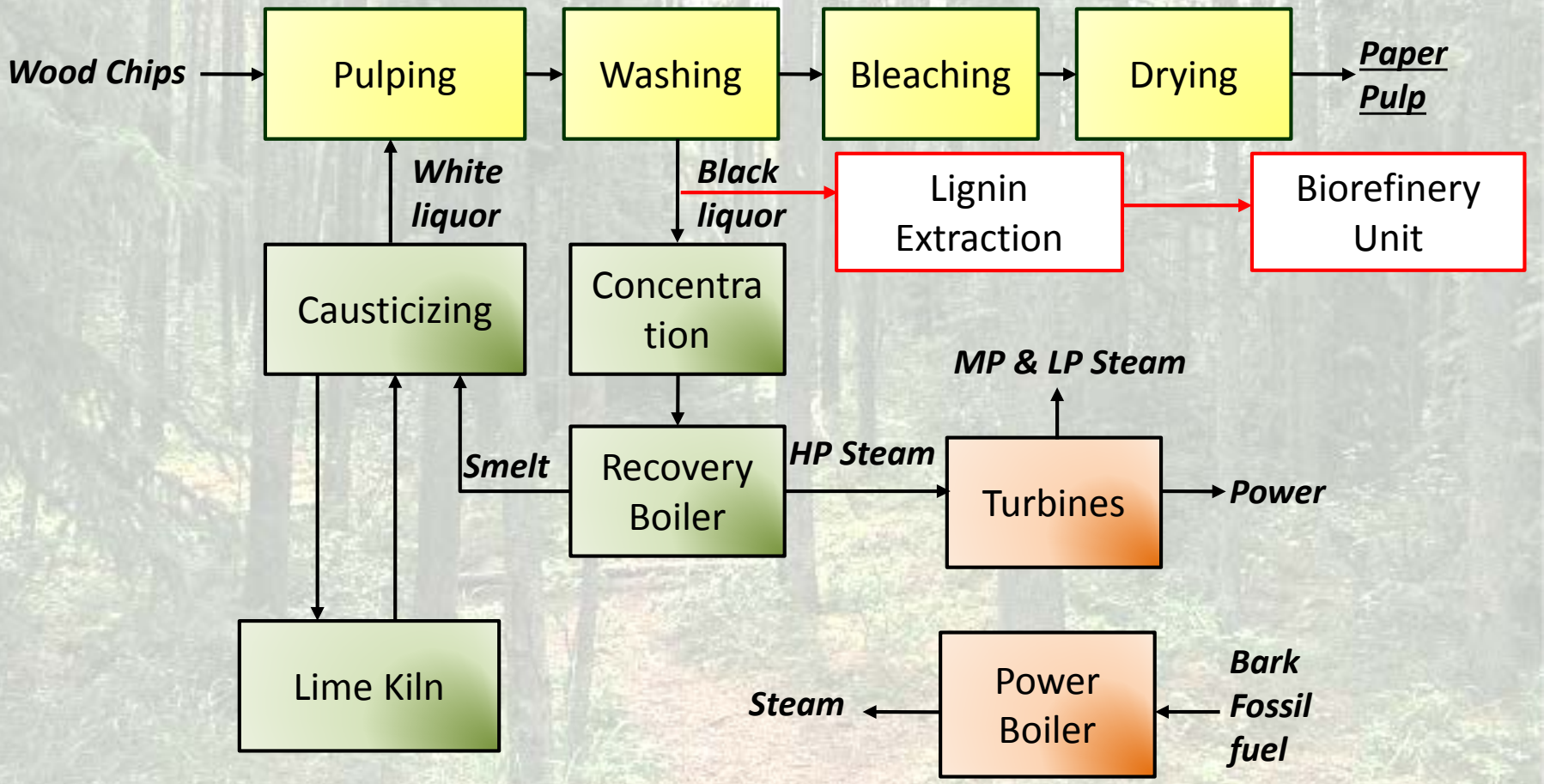
The Concept of Integrated Forest Biorefinery



Receptor Mill: Dissolving Pulp Process

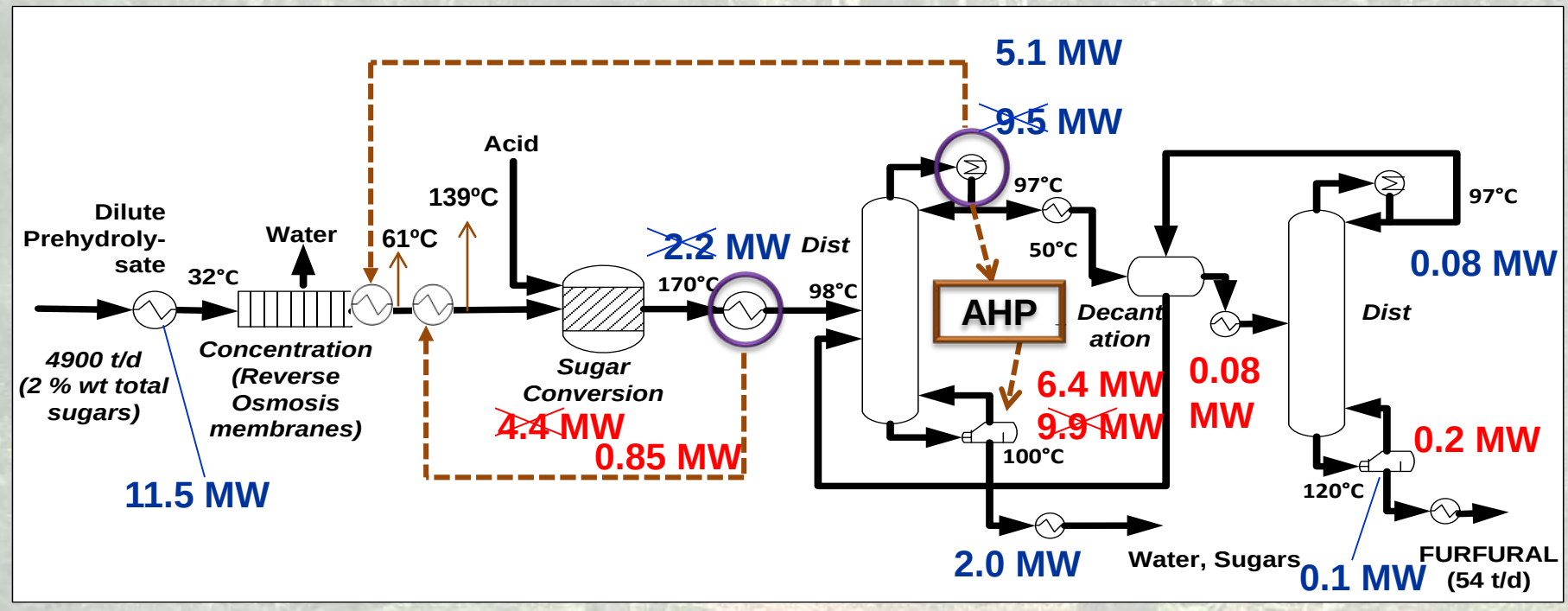


Lignin Biorefinery: Paper Pulp Mill



Furfural Process, Energy Requirement

- Total heating requirement (ΣQ_H) = ~~14.6~~ MW → 8.0 MW
- Total cooling requirement (ΣQ_C) = ~~25.6~~ MW → 19.0 MW



An Industry at a Turning Point

- The integrated forest biorefinery may be a very effective way for the P&P industry to expand its products portfolio and penetrate new markets.
- It must reduce/eliminate fossil fuel consumption (NG) by energy intensification to reduce operating costs (10-25%) and GHG emissions.

A new methodology to analyse and enhance the thermal energy efficiency of Kraft pulping mills has been developed and validated in three mills.

A Novel Methodology For Energy Efficiency Analysis

Main Characteristics

- Stepwise, project oriented procedure
- Combined steam and water systems
- Use of heuristics
- Process simulation aided method

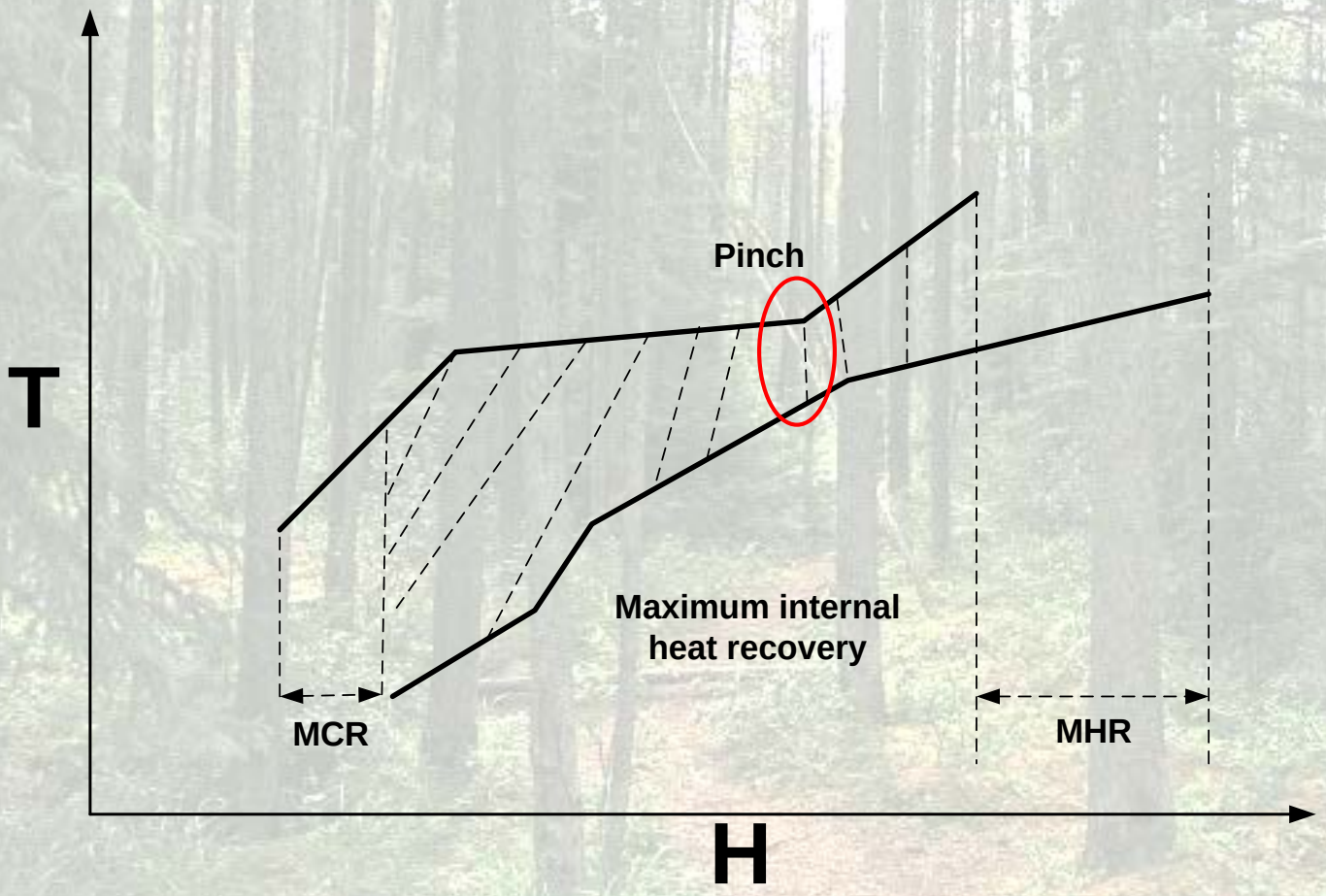
Validation

Applied to three operating Canadian Kraft mills

Results far superior to current practice

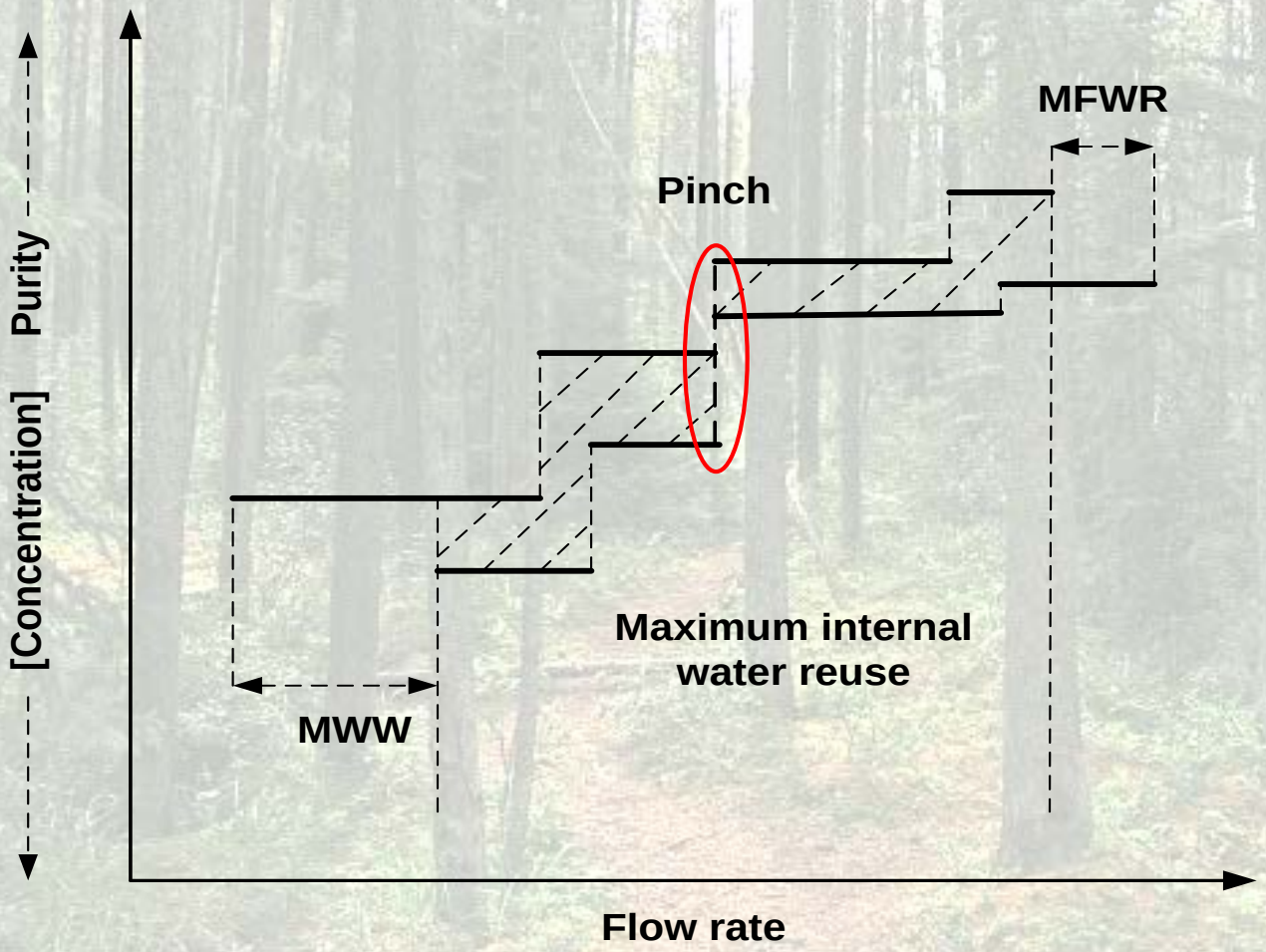
Thermal Pinch Analysis

Hot and cold composite curves

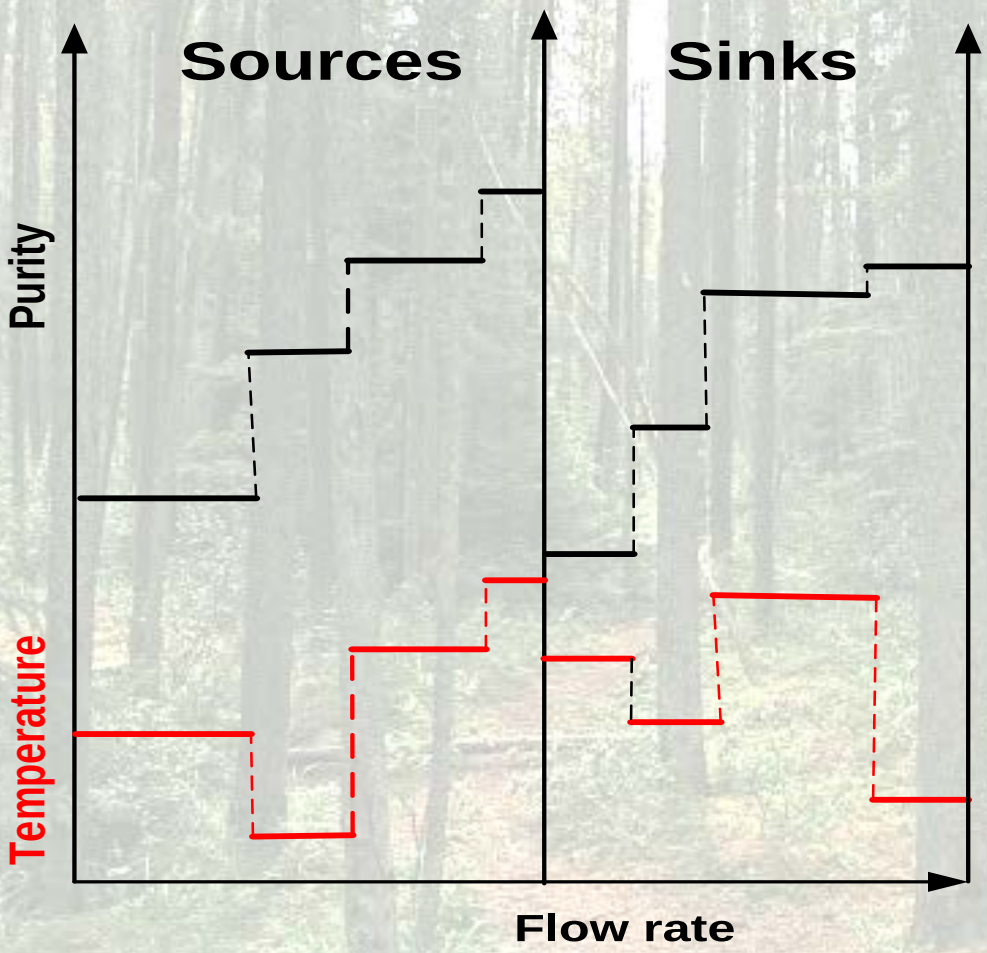


Water Pinch Analysis

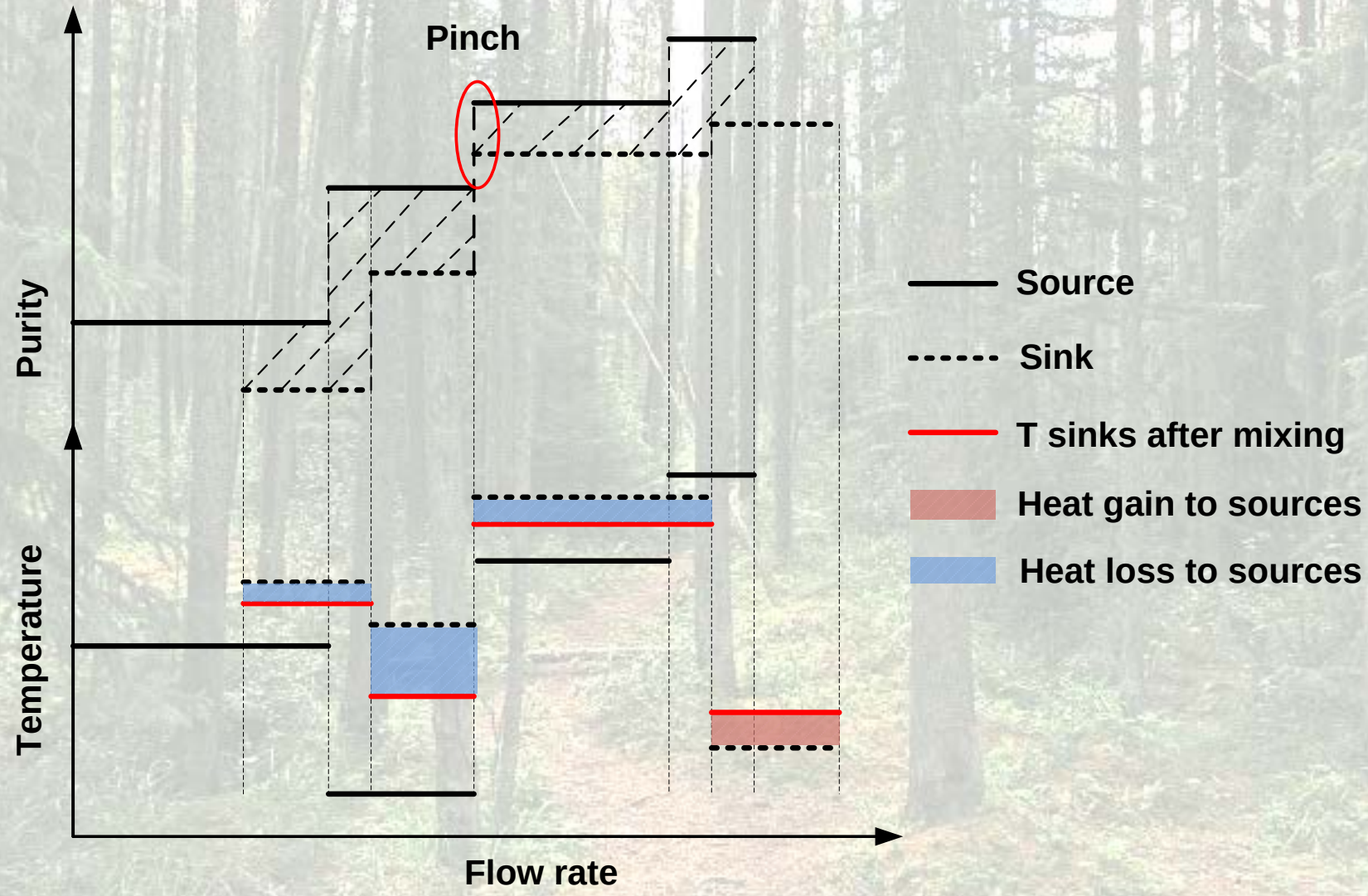
Sources & Sinks diagram



Combined mass and energy representation of water streams



Dual Heat and Mass Analysis of Water Systems

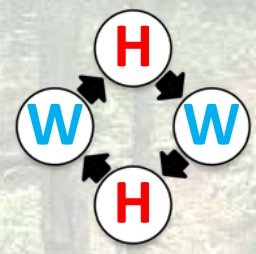


Limitations of Pinch Analysis

- It considers only streams involved in current design
- Ignores important exchange modes
  - Cooling by mixing and diluting
  - Simultaneous heat and water exchanges

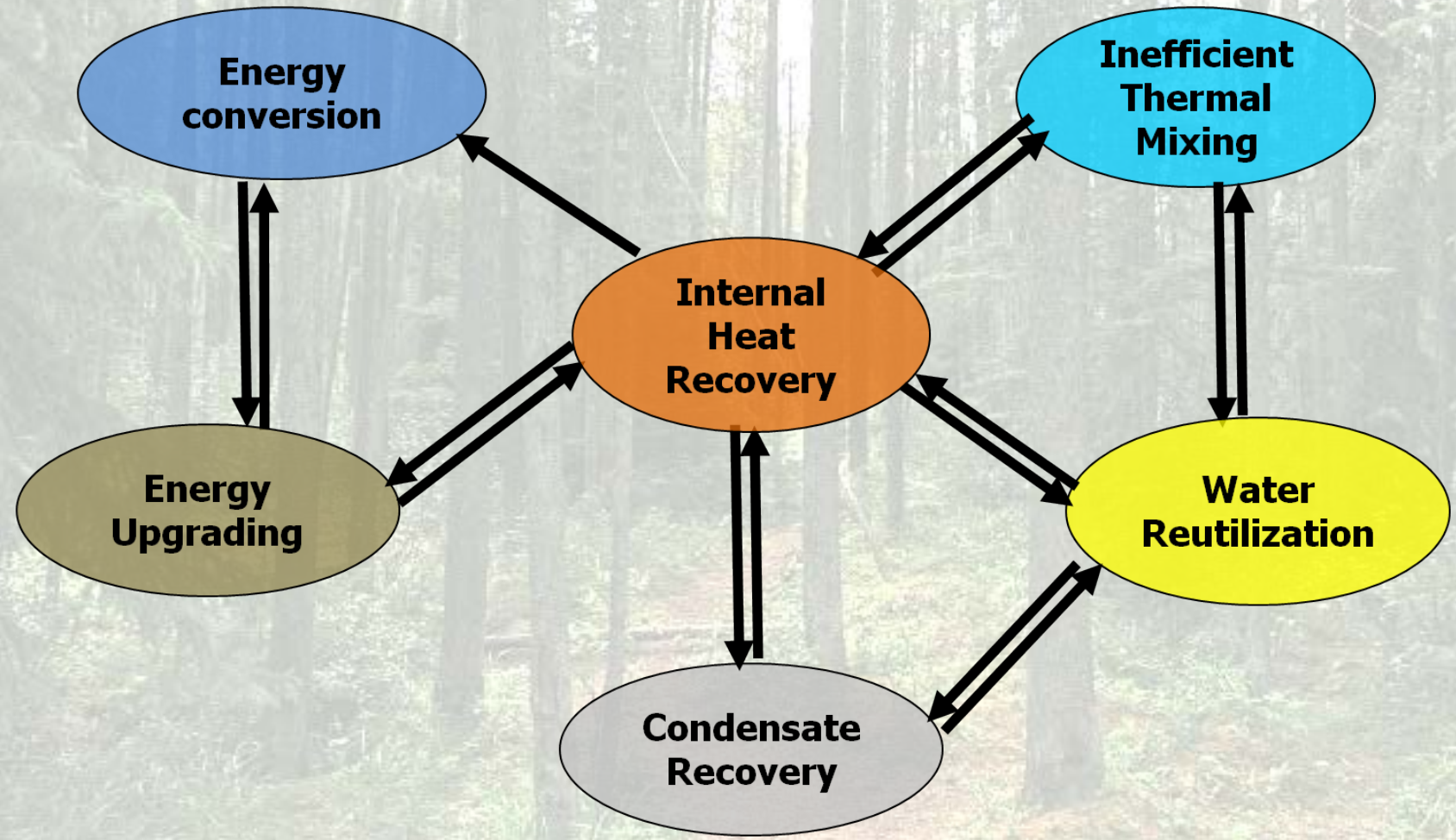
SOLUTION

- Iterative analysis →

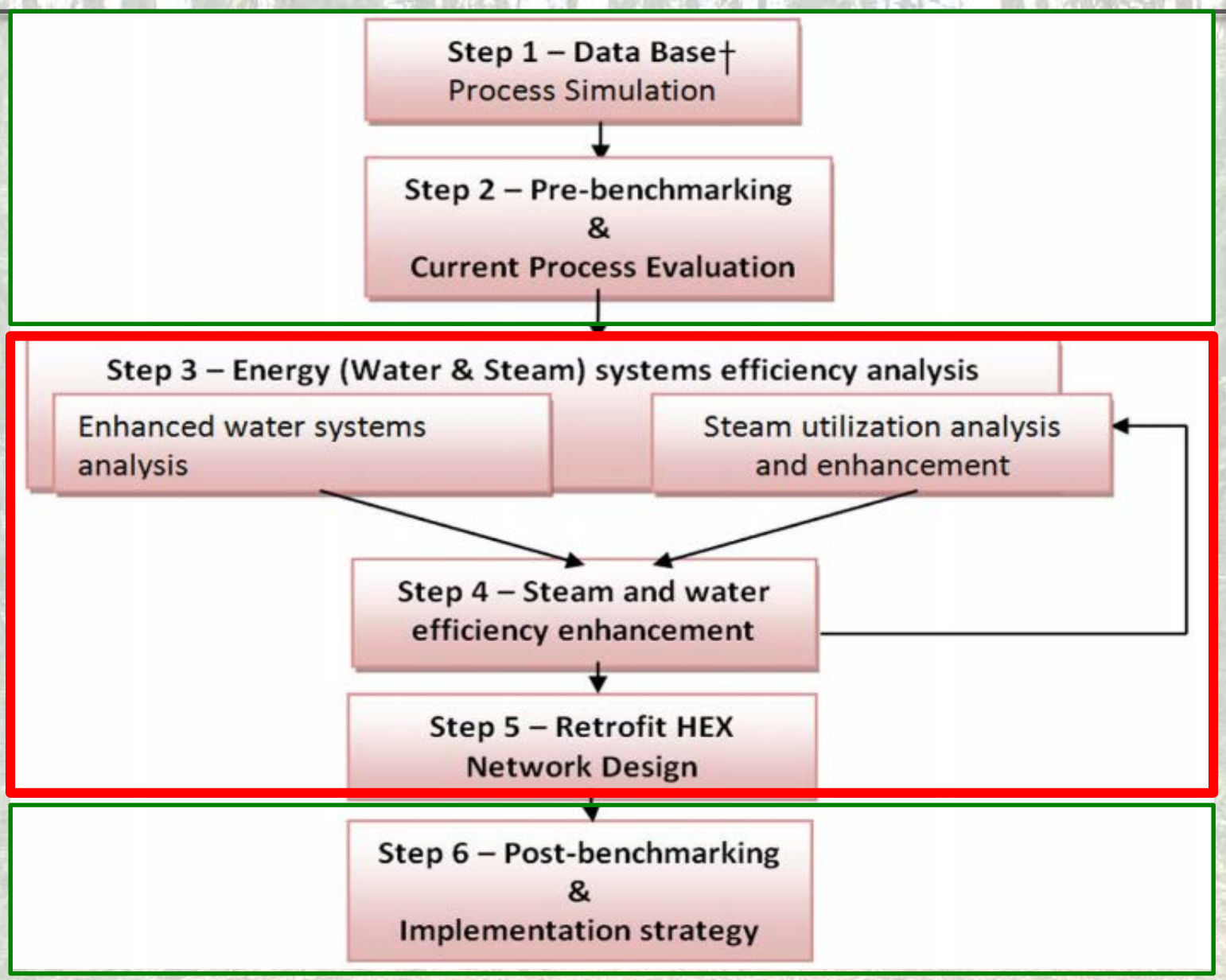


- Extension of the analysis to other exchange techniques

Interaction Between Energy Transfer Systems

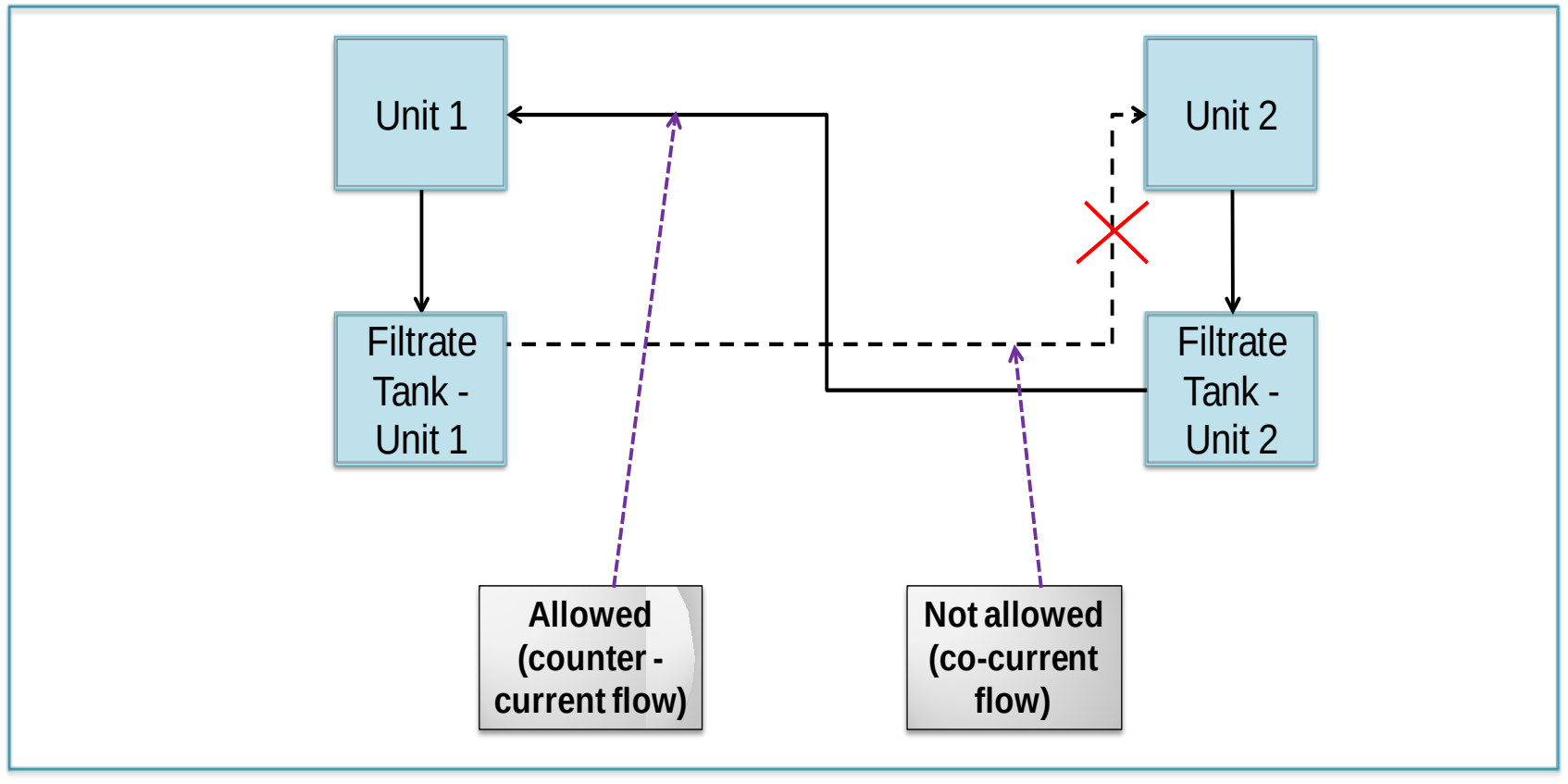


A Stepwise Methodology



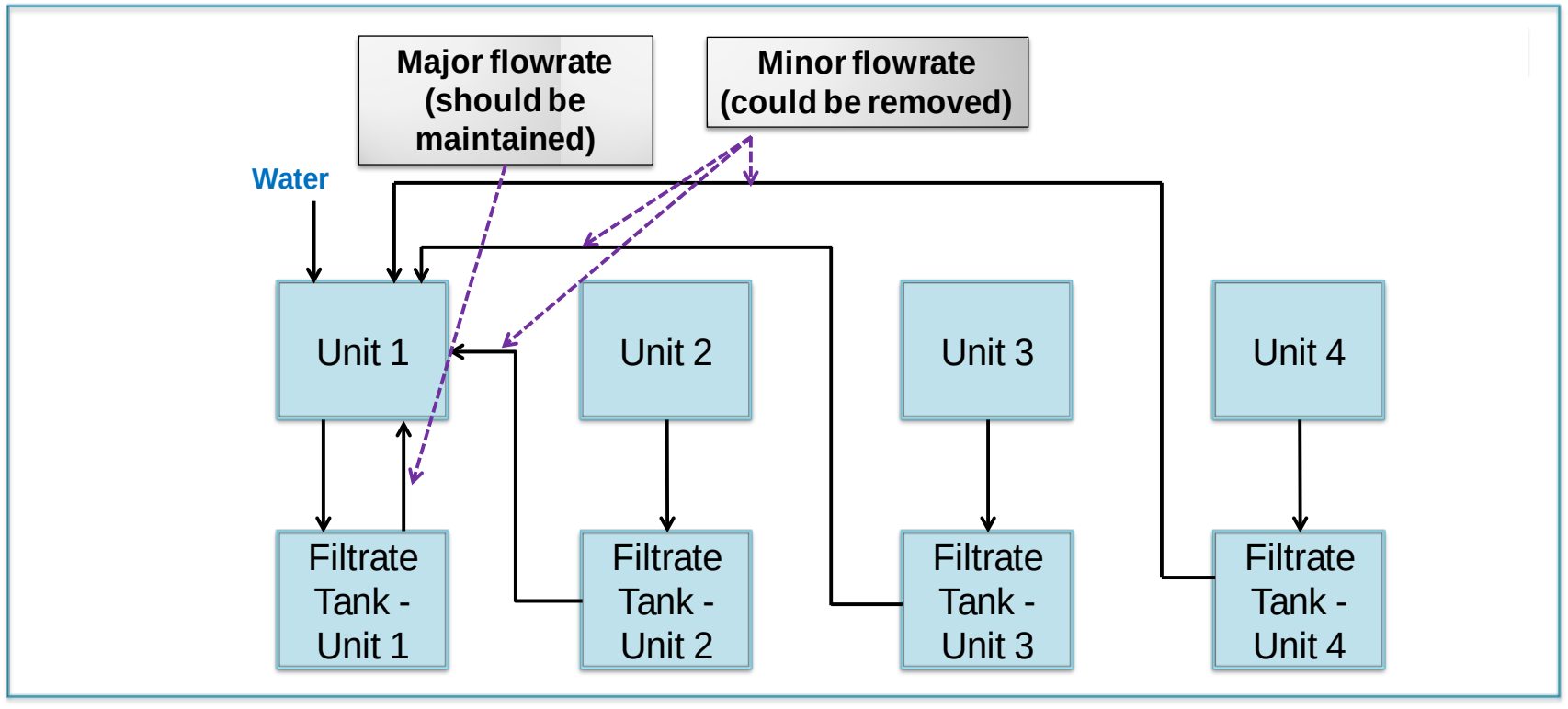
Heuristic Rule # 1

Cascading countercurrent water flow (filtrate)



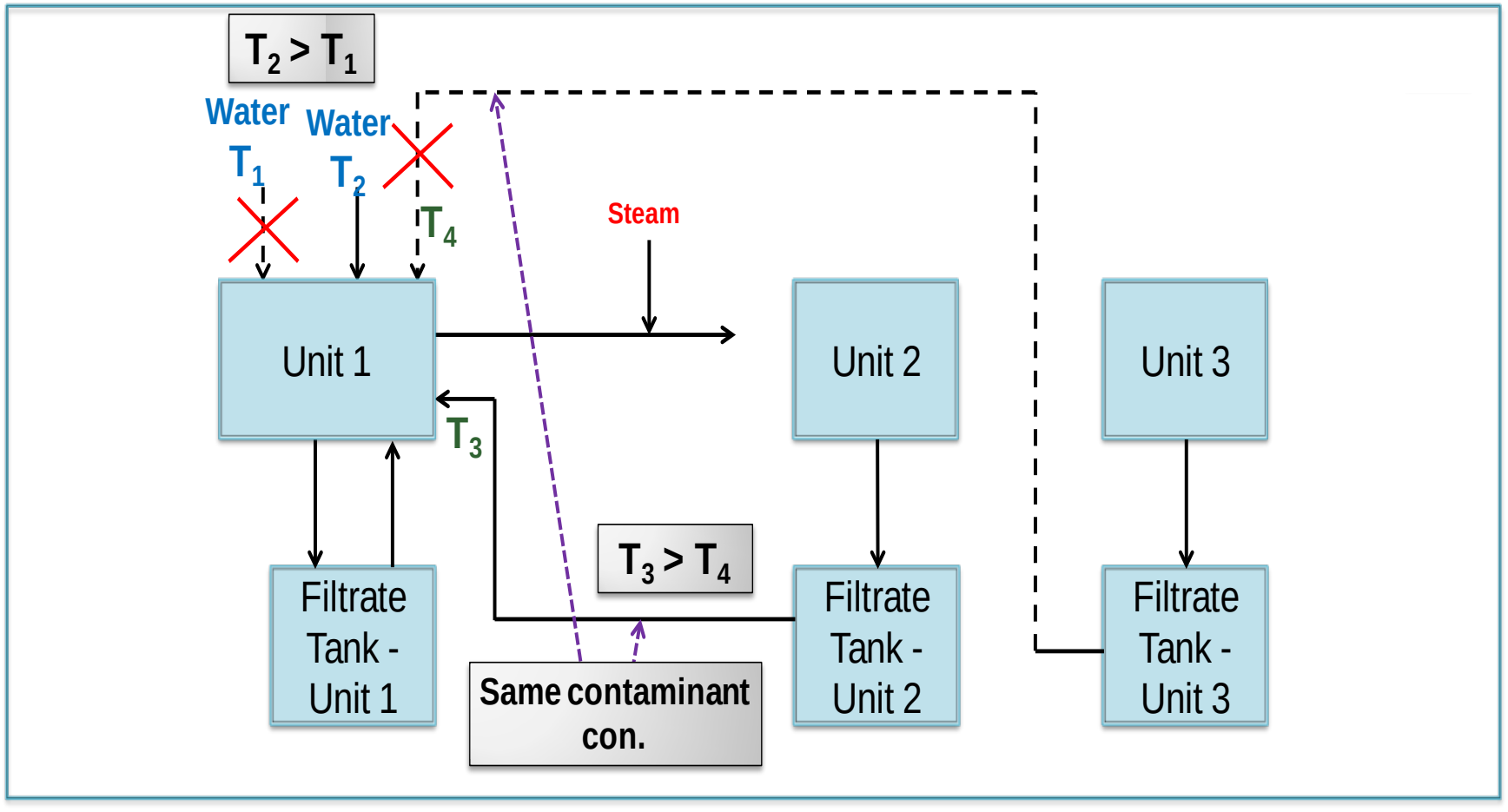
Heuristic Rule # 2

Give priority to water streams with higher flowrate



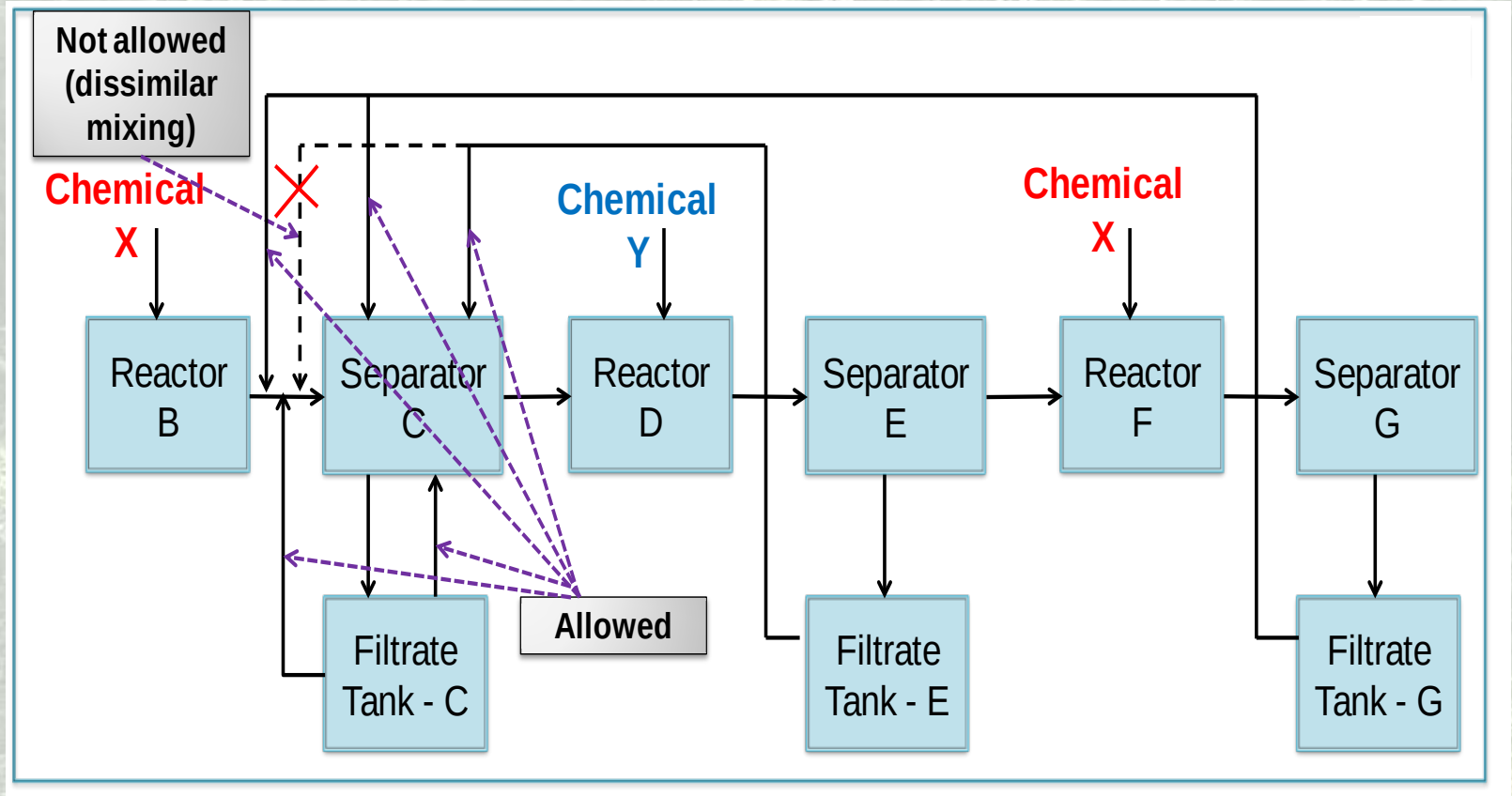
Heuristic Rule # 3

Use high temperature water streams rather than steam

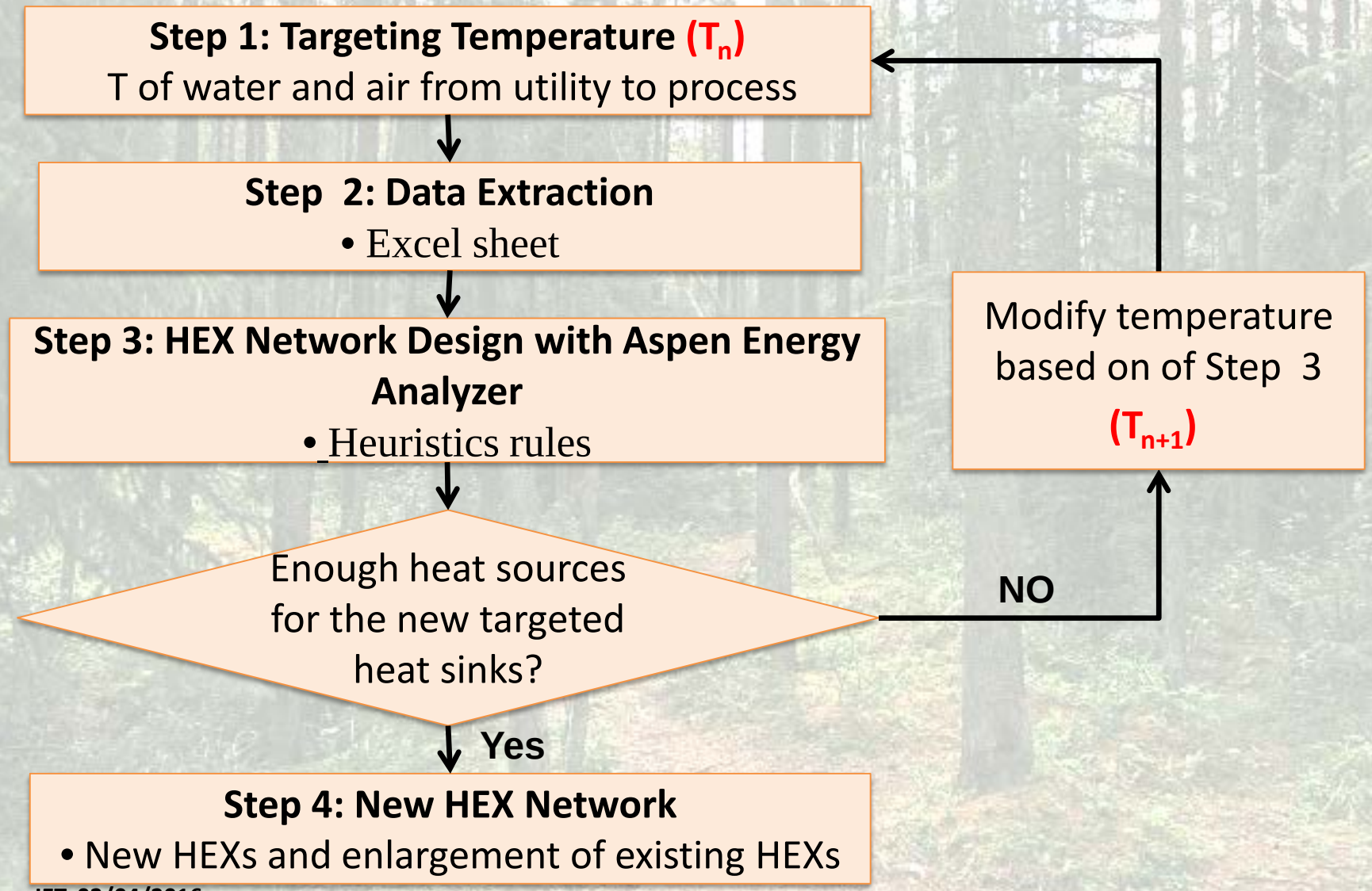


Heuristic Rule # 4

Do not mix streams of different compositions

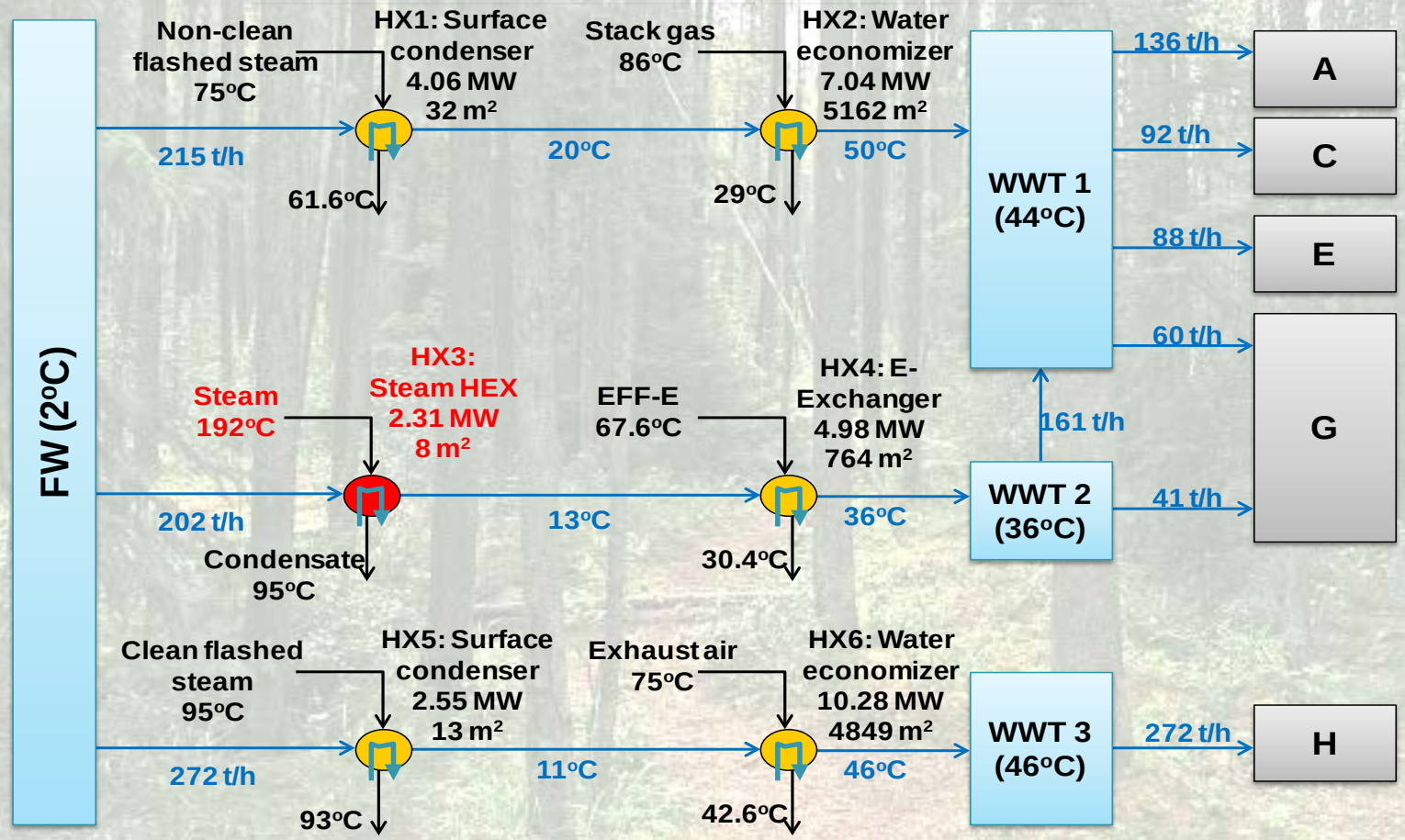


HEX Network Redesign



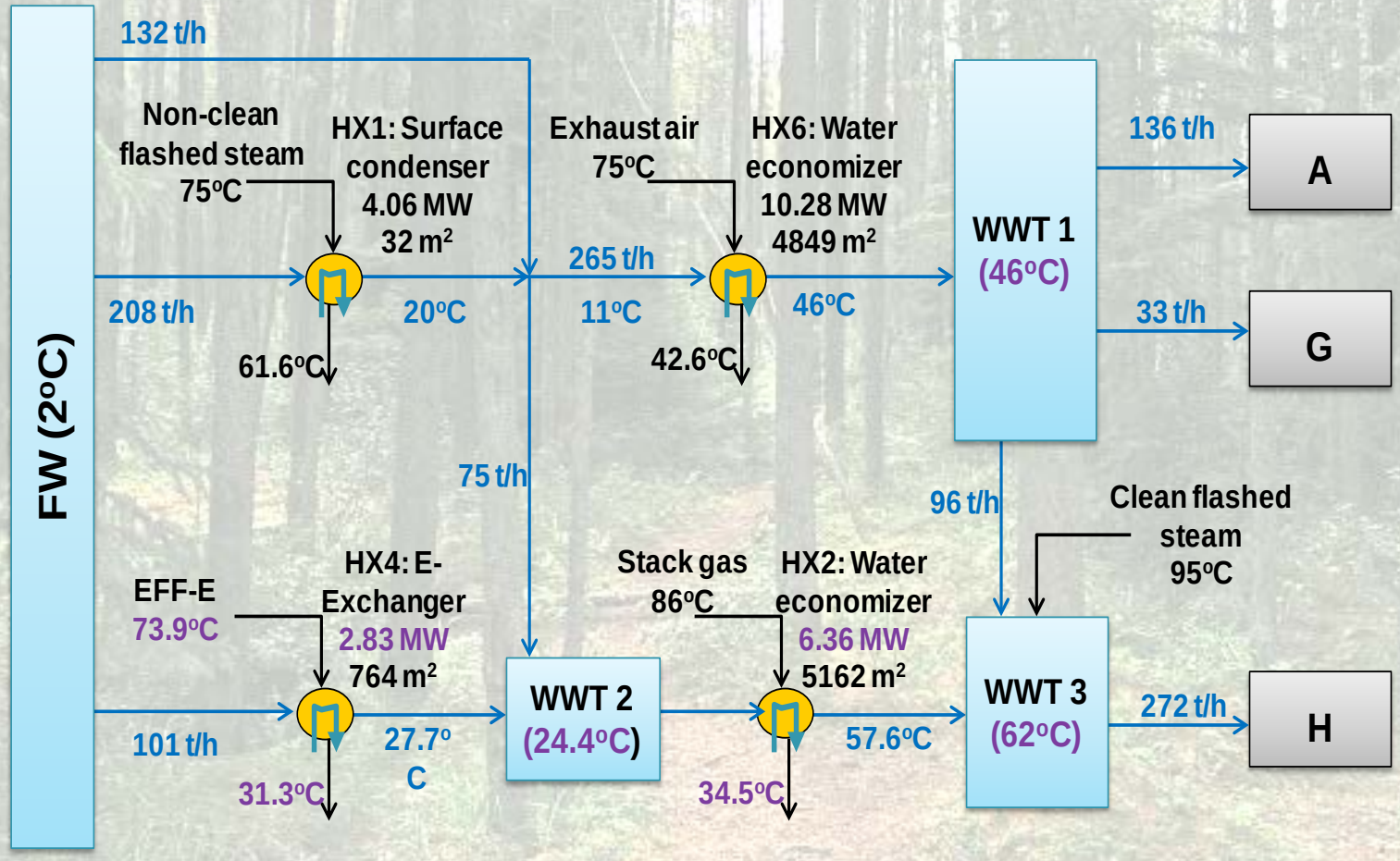
Results: Hot and Warm Water Network

Current

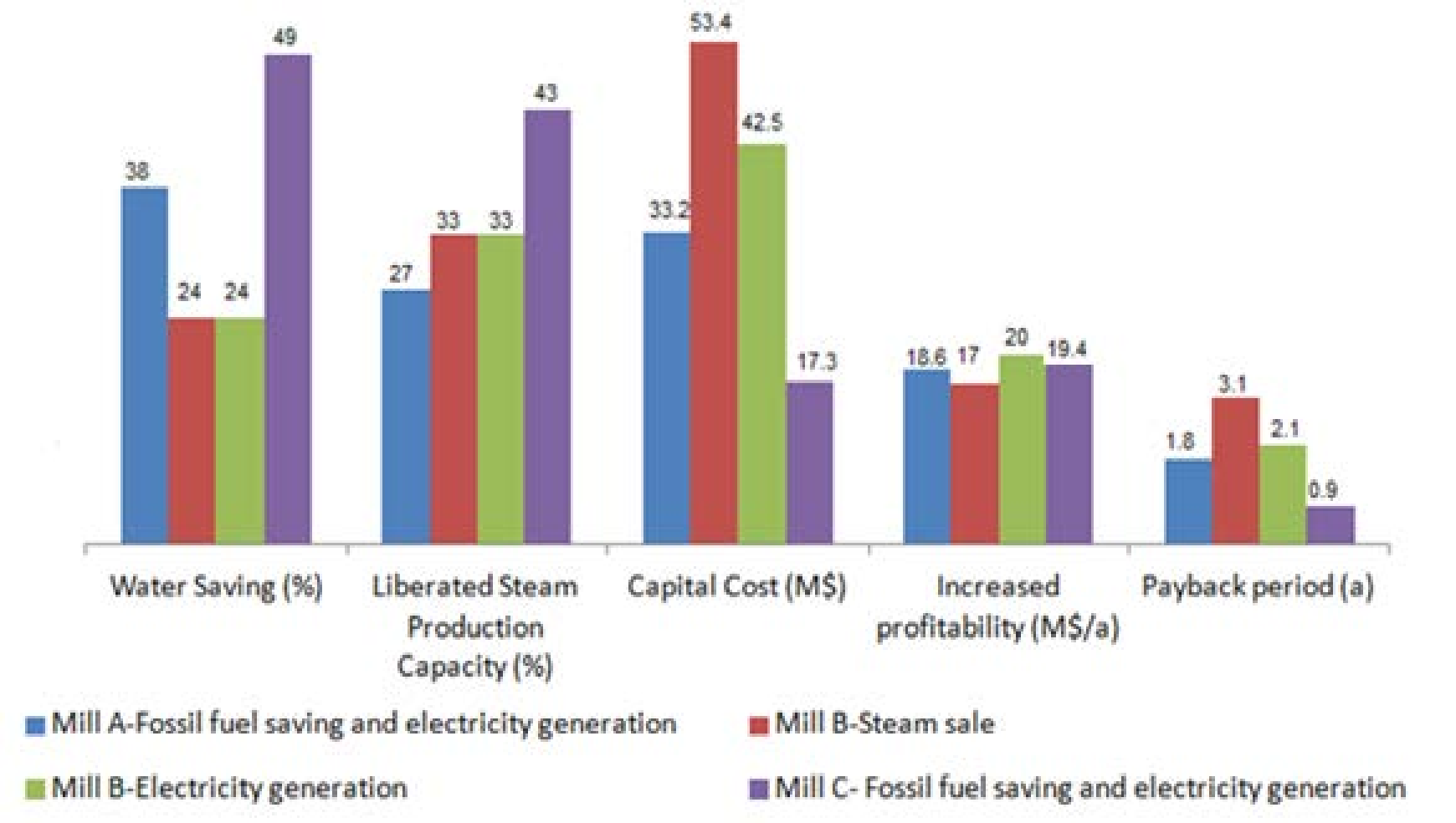


Results: Hot and Warm Water Network

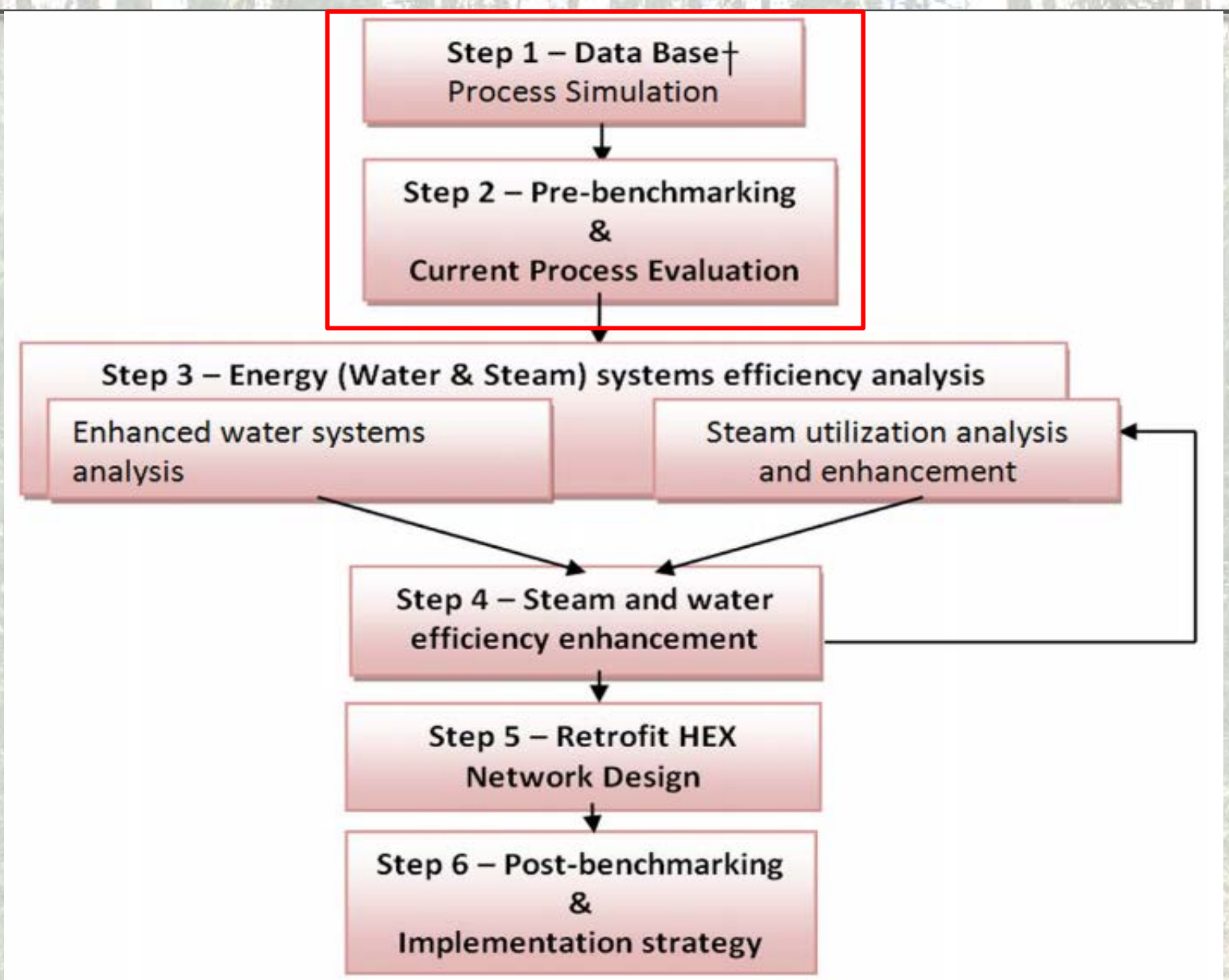
New Configuration



Results: Three Kraft mills with different strategies



Work In Progress



Data Base

- Simulation of an operating plant on a Cadsim Platform
- Utilization of mill daily measurements archived in Virtual Private Network connection (VPN)
- Reconciled mass and energy balances of the operating plant
- Identification of outliers (erroneous measurement or faulty performance)

Results:

•Simulation represents a long-term steady state average

• Heat and mass balances are coherent

Equipment Performance Analysis

- Unit operations and equipments do not always operate as intended
- Equipment Performance Indicators:

Identification	• Characterisation of equipments through new Key Performance Indicators (KPIs)
Diagnostics	• Evaluation of the current state and identification of inefficiencies through the KPIs used
Improvement	• Proposal of improvement projects based on the diagnostics made

- Exergy is the portion of the total energy of a system that can be converted to useful work
- It is a Key Performance Indicator for energy utilization.
- Identifies the maximum theoretical efficiency enhancement

Conclusions (1/2)

- A systematic methodology for the energy efficiency enhancement of water-based processes has been developed
- It incorporates innovative developments
  - Combined water and energy analysis
  - HEX network retrofit design
  - *Reconciled database*
  - *KPIs based on exergy*
- Project oriented supported by heuristic rules
- Current version focused on Kraft processes, can be generalized to other water based processes

Conclusions (2/2)

- The methodology has been applied to operating Kraft pulping mills and produced results far superior to current engineering practice
- In it's current state of development, it is operational and validated at the conceptual algorithm stage
- Work is envisaged to develop a portable computer aided version

• Rigorous analysis
•Heuristic rules
• Project oriented

Acknowledgement

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We acknowledge the contributions of following parties

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Thank You!

Questions