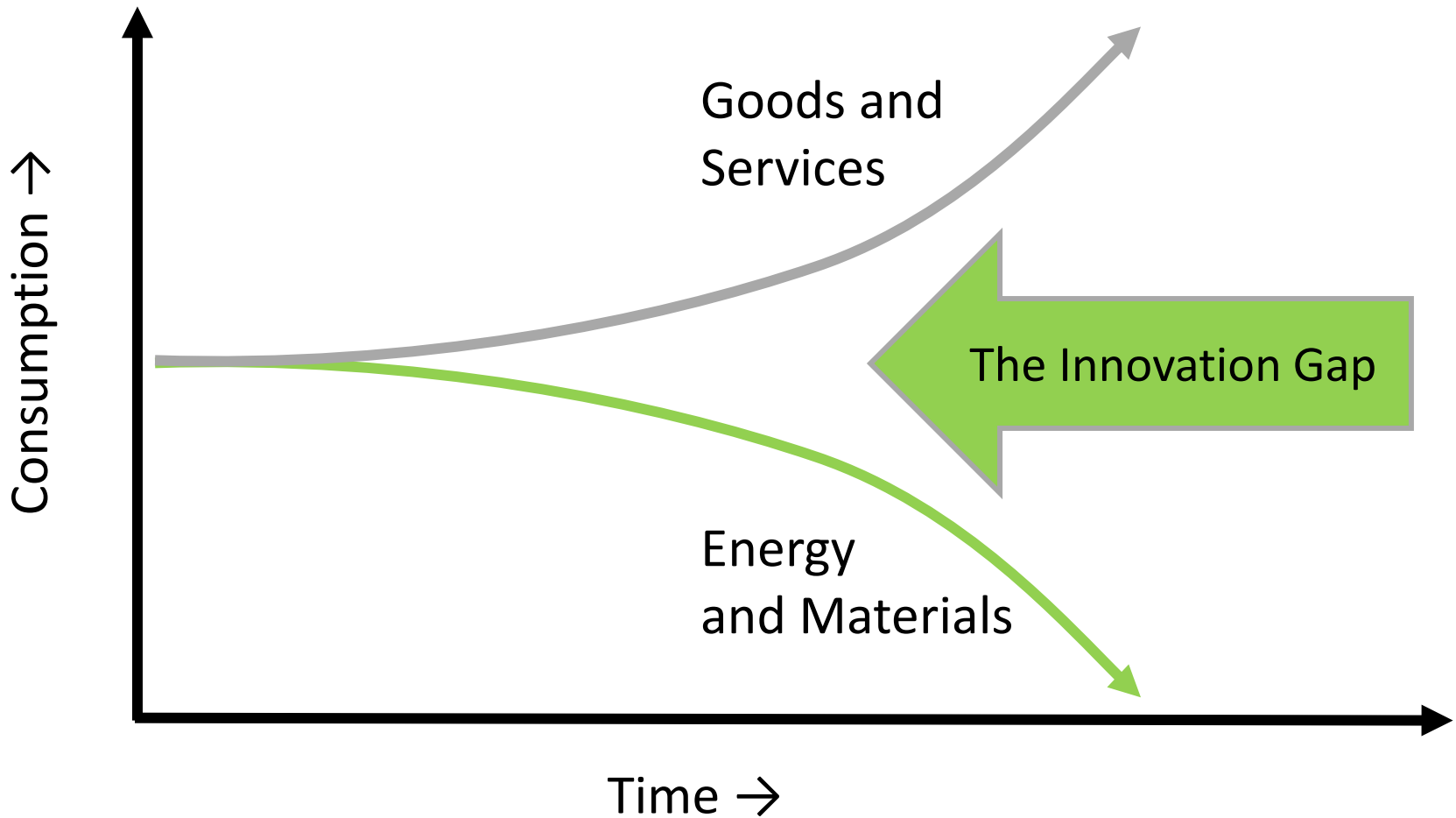




# Sustainable Aviation Fuels: An Industrial Ecology Perspective

ICAO Seminar on Alternative Fuels  
February 2017

Michael Lakeman, Ph.D.  
Environmental Strategy & Integration  
Boeing Commercial Airplanes

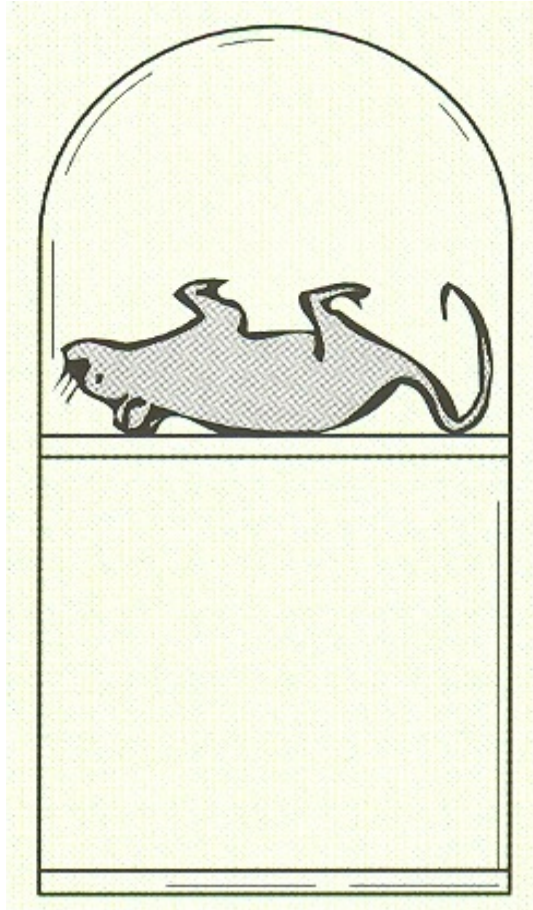


### Innovation Required in:

- Technology
- Policy
- Risk Sharing/Business Models
- Project Conceptualization

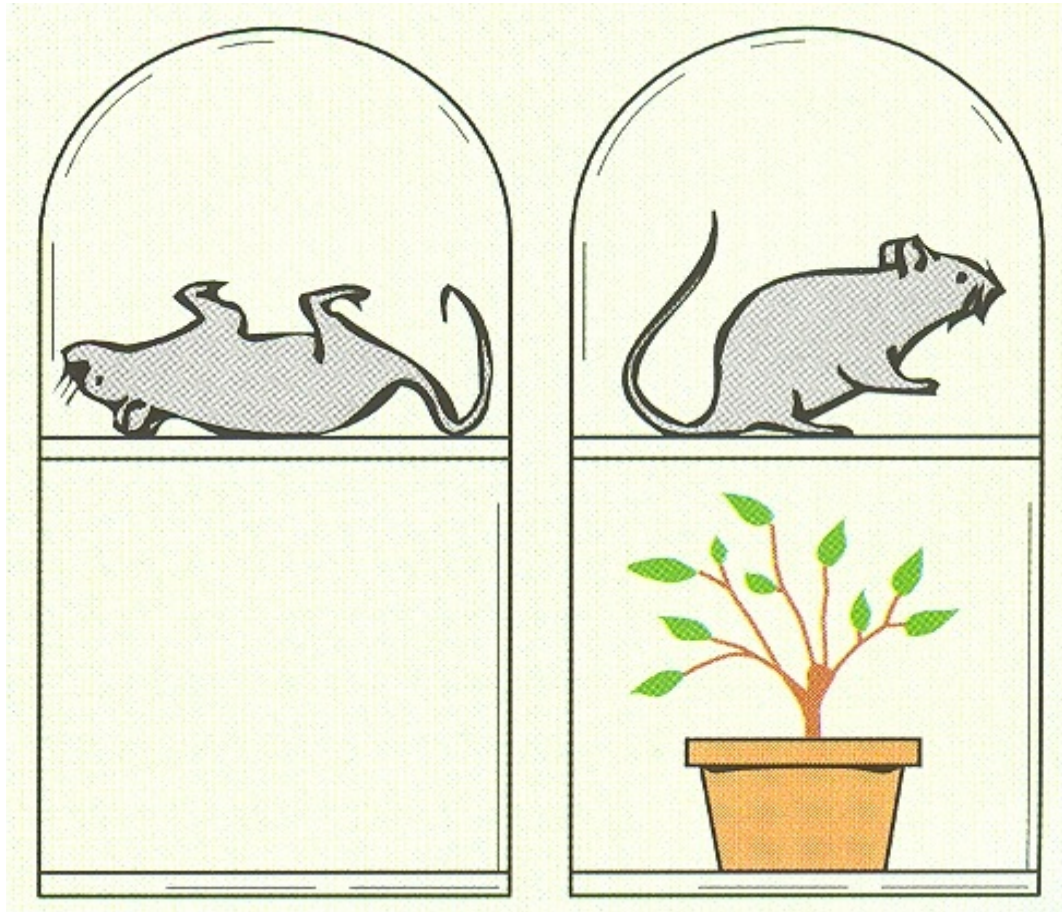
# What is Industrial Ecology?

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# What is Industrial Ecology?

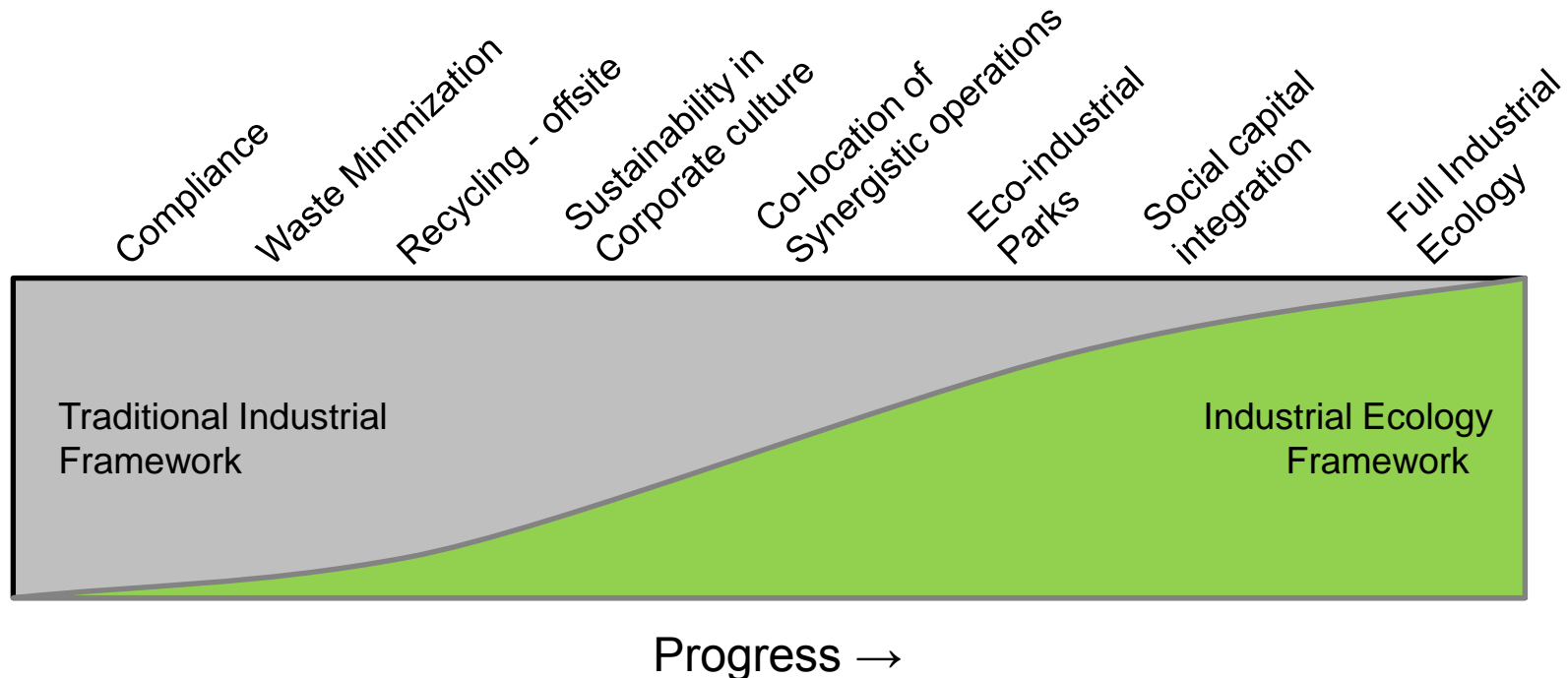
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# What is Industrial Ecology?

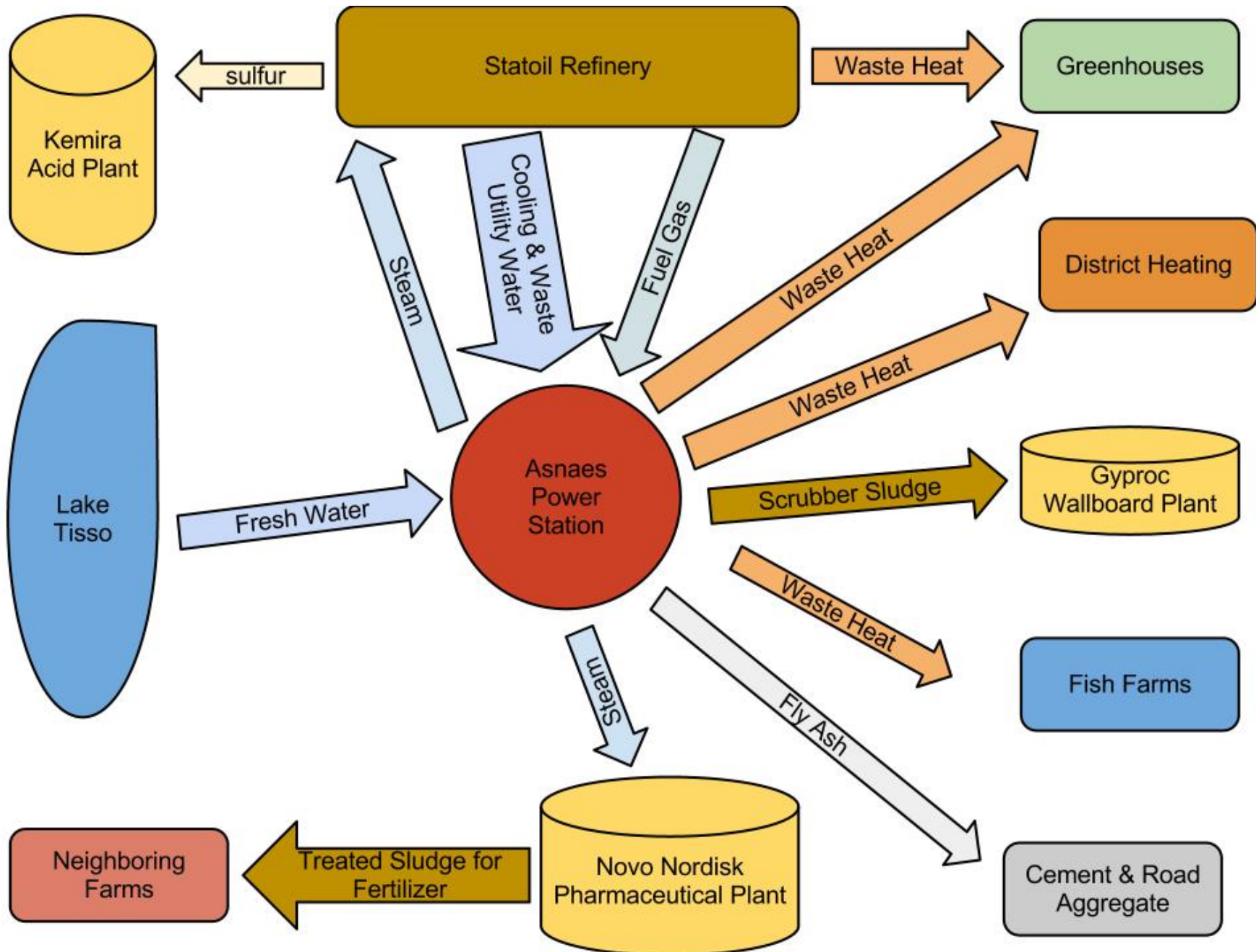
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A framework for designing sustainable industrial systems through analogy to natural ecological systems



# Kalundborg, Denmark





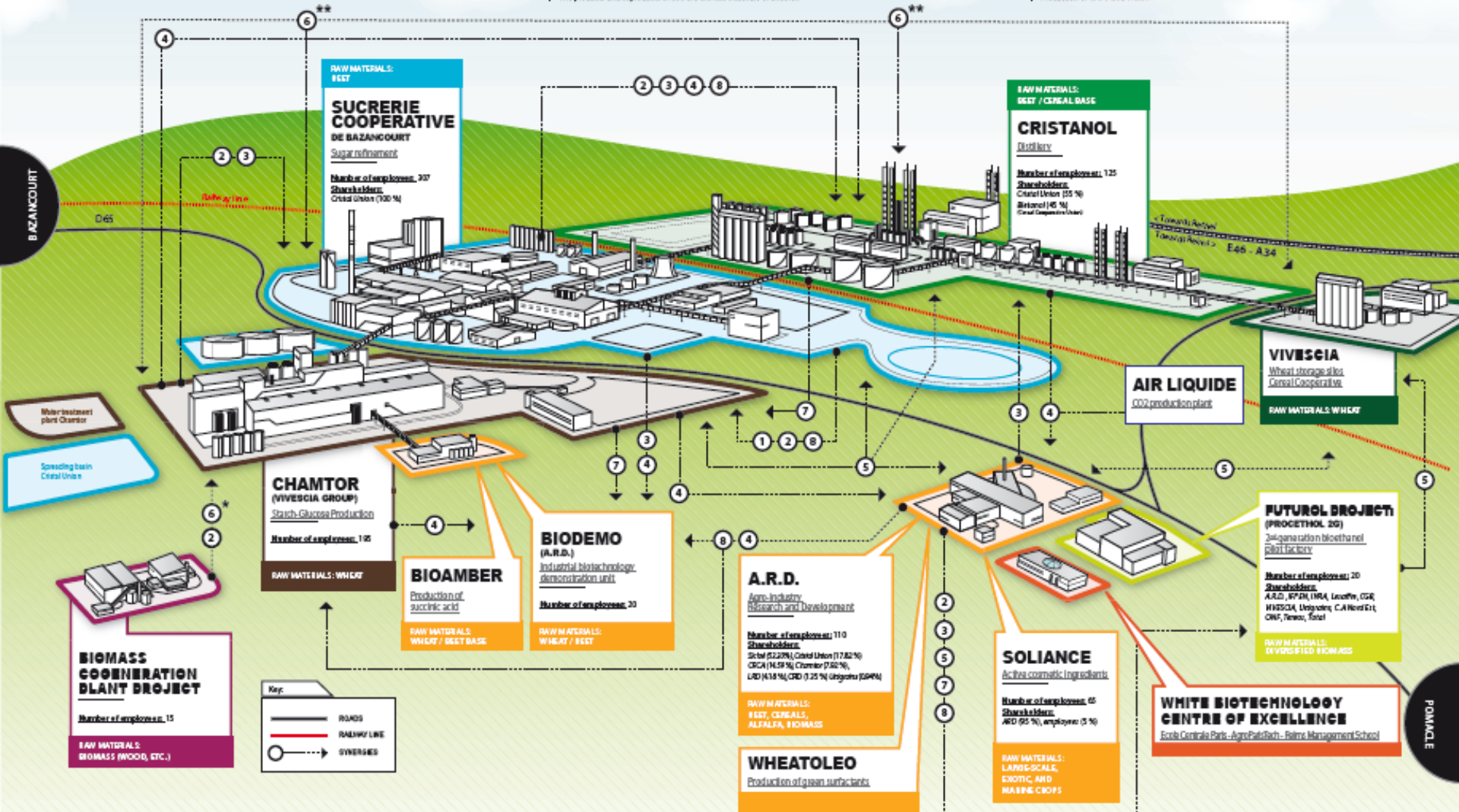
# "Les Sohettes" industrial zone

Bazancourt - Pommacle

## POSITIONING AND SYNERGIES

- 1 WATER synergies :** Condensate recovery  
50,000 m<sup>3</sup> of excess condensate used by Chamtor during the last year.  
Advantage : Less drilling of the water table and recovery of energy.
- 2 STEAM synergies**  
Reprocessing steam recovery.  
Advantage : Increased reliability of industrial facilities.
- 3 EFFLUENTS synergies**  
PURIFICATION - STORAGE - SPREADING  
Advantage : Overall agronomic maturity and approach.
- 4 PRODUITS synergies**  
The products and coproducts of one are the raw materials of another.

- 5 R&D synergies**  
Research programmes decided in cooperation with A.R.D.'s agro-industrial shareholders.
- 6 ENERGY synergies**  
Production of bioethanol from bioenergetic coproducts.  
\* Energy synergies: Use of steam produced by cogeneration  
\*\* Energy synergies: Production of bioethanol
- 7 ORGANISATIONAL synergies**  
As part of the I.A.R. competitiveness hub the following organisational synergies have been implemented:  
Assistance for the construction and the exploitation of facilities and training programmes.
- 8 DRILLING synergies**  
Production of untreated water.





# Why is this relevant for sustainable aviation fuels?

- Low value product needs low cost input
- Low value product requires additional value through
  - Other products
  - Other services
- High capex requirements, can capital be shared or leveraged?
- Wary capital markets mean strategic investors are key



Bio-Refinery

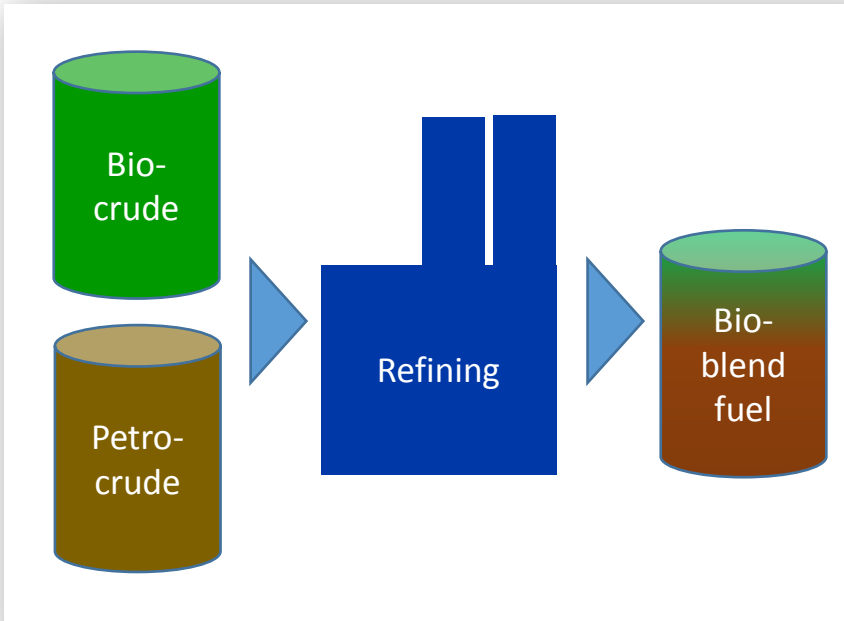
Mutualism, benefiting both parties...



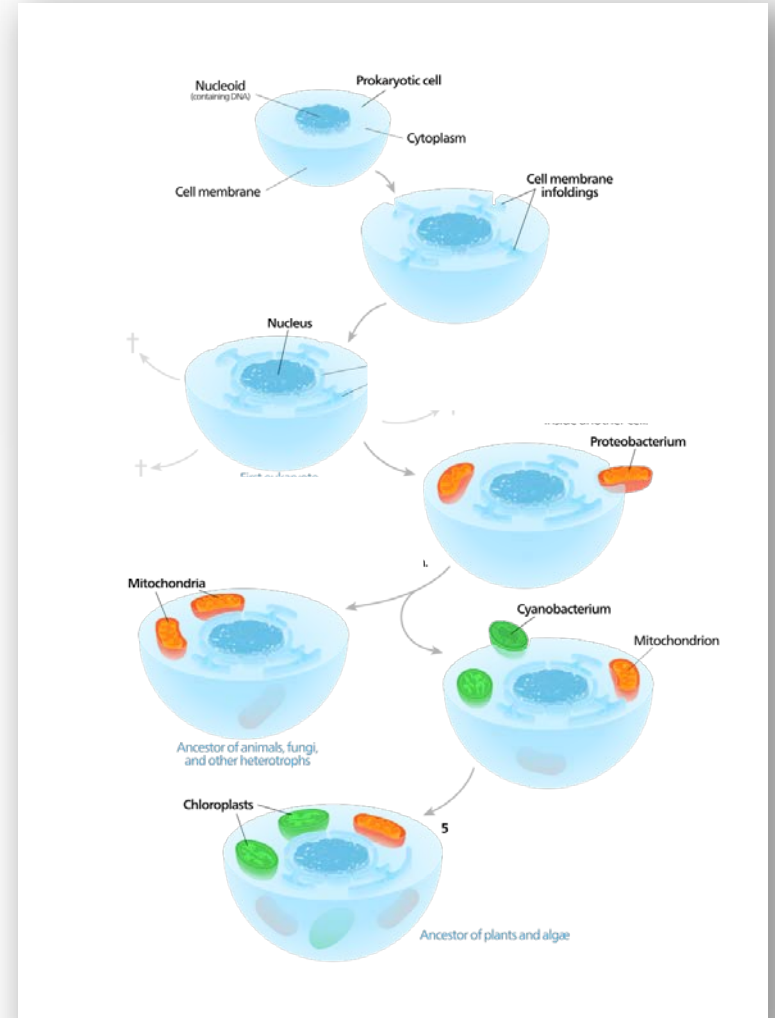


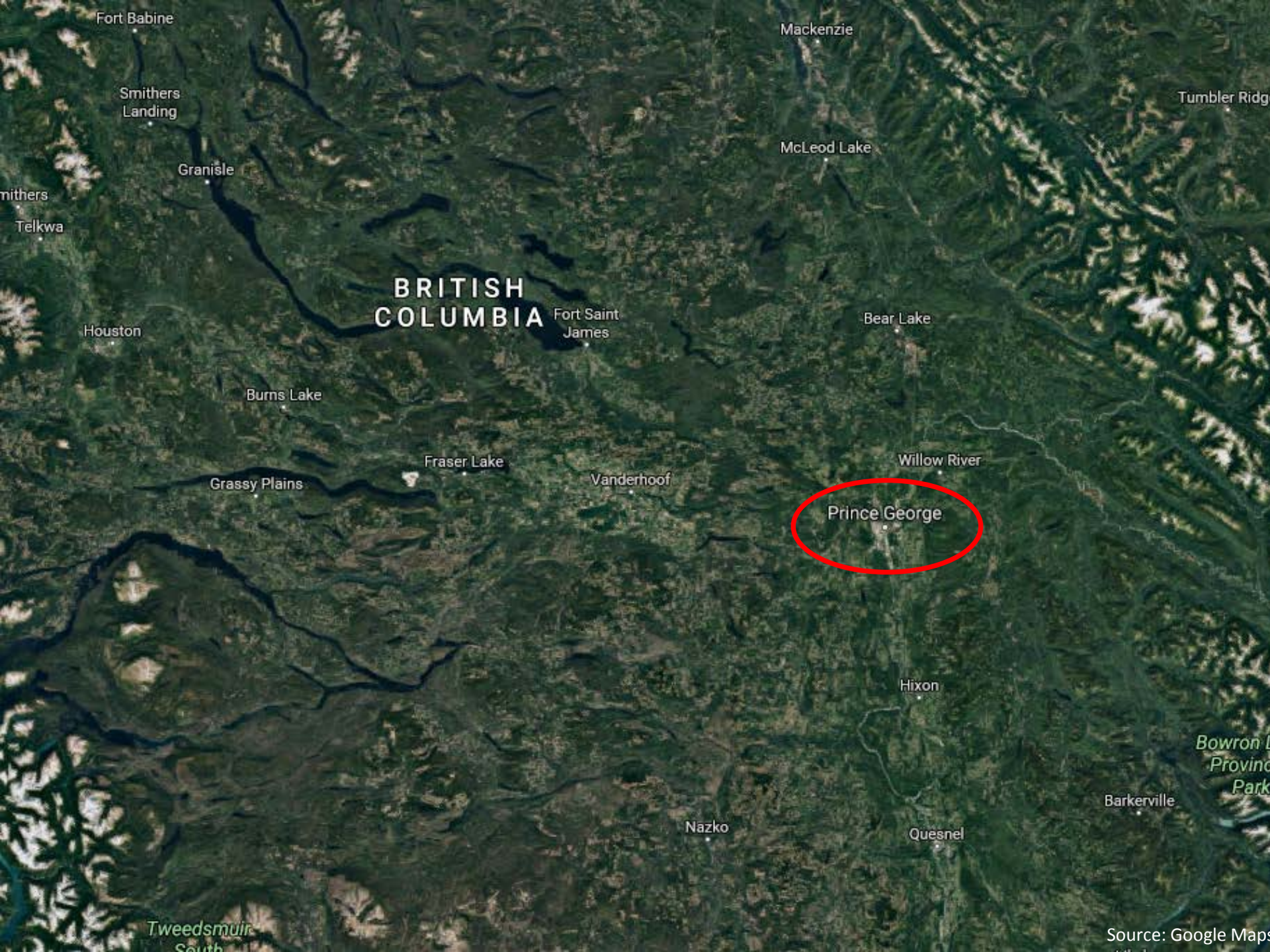
New life springing from old...





Endosymbiosis; the big guys gaining function by absorbing the little guys...





**BRITISH  
COLUMBIA**

Prince George

# Canfor/Licella JV Project for Catalytic Hydrothermal Liquification of Forestry and Pulp Mill Residues



Petroleum Refinery`

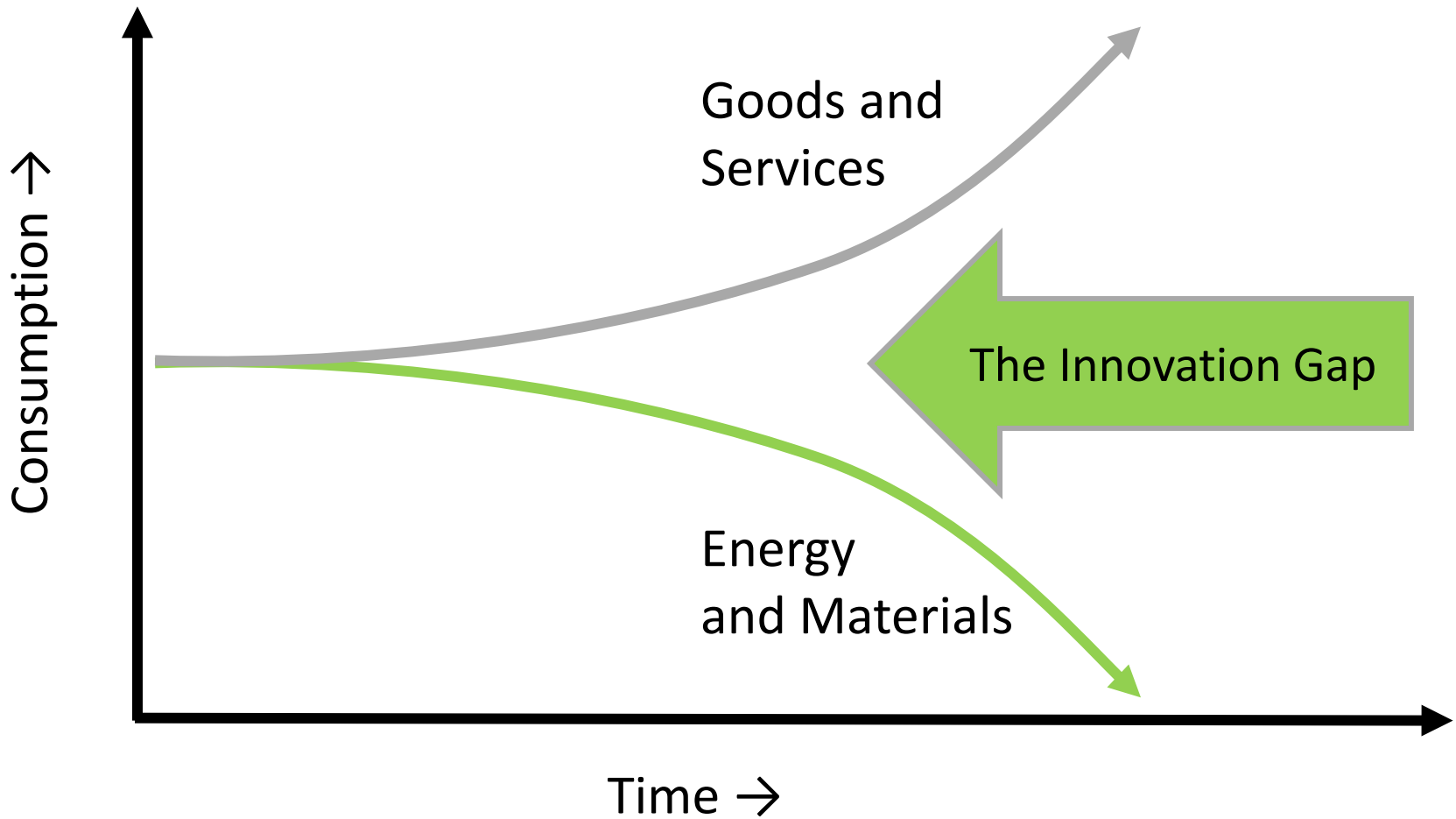
Fraser River  
Transportation Infrastructure

Wastewater Treatment

Fraser River  
Chloralkali Plant  
Hydrogen

Canfor Pulp Mill  
Feedstock  
Skilled Workforce  
Heat/Steam





Innovation Required in:

- Technology
- Policy
- Risk Sharing/Business Models
- Project Conceptualization

# Three policy requests (to encourage Industrial Ecology)

1. Local authorities central to eco-industrial development
2. Facilitate Public-Private-Partnerships
3. Internalize the cost of externalities