

Promoting International Collaboration
on
Energy Efficient Bioprocesses

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Industrial Bioprocessing and the Biobased Economy

Challenges and Opportunities

John Jaworski, Ph.D.
Life Sciences Branch
Industry Canada

The Challenge for the 21st Century is Sustainability

The present level of global energy consumption
& industrial growth/production
is ultimately not sustainable
because it is only made possible
by continued withdrawals
from the stored “bank” of fossil carbon
which is finite and not renewable.

Restated ...

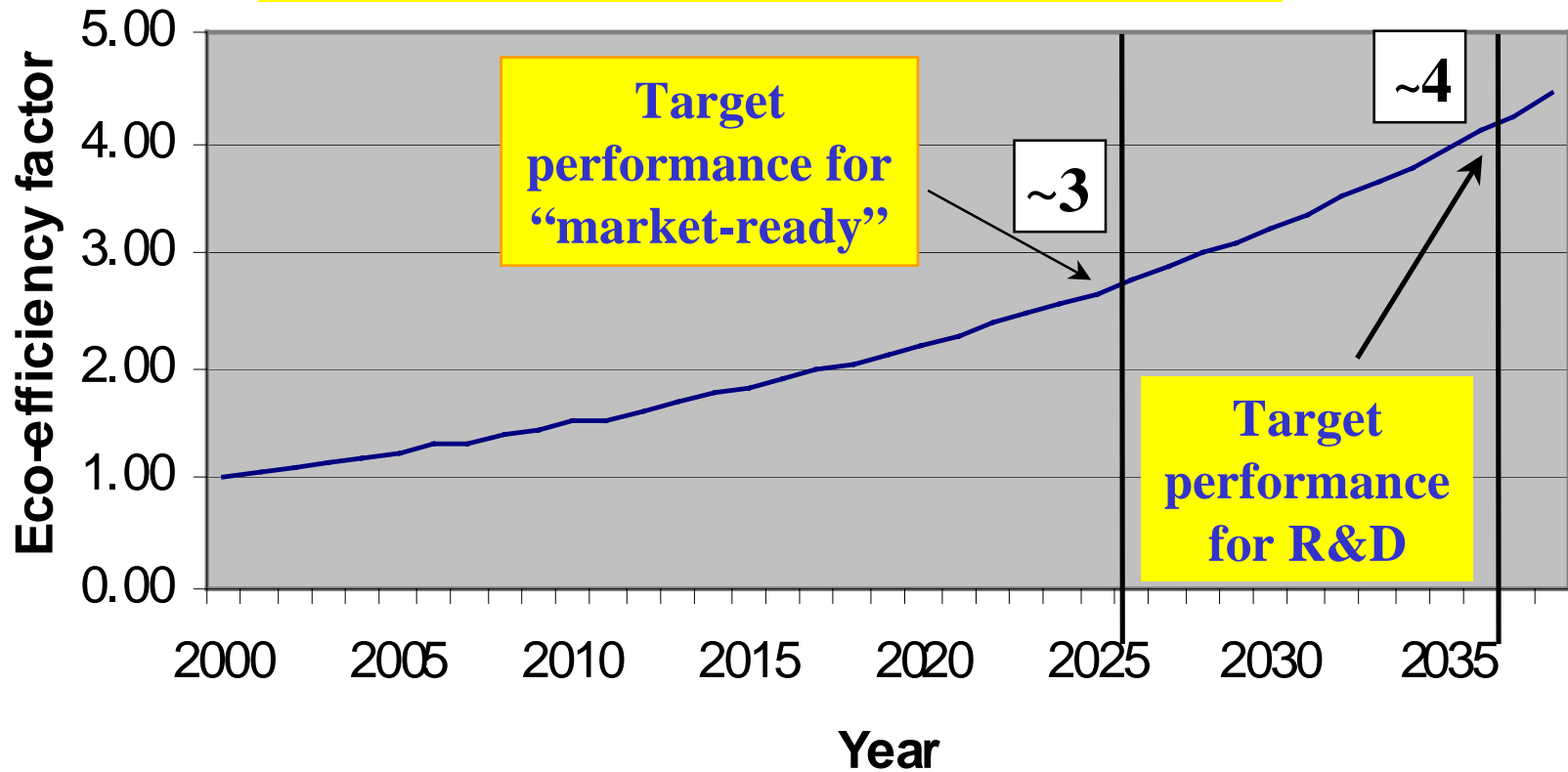
The problem with our global industrial system is that it is steadily growing larger in comparison with the natural environment so that its outputs are reaching levels that are damaging because of their sheer volume, regardless of whether they are traditional pollutants or not (e.g. CO₂)

Setting Realistic Targets

The eco-efficiency of industrial processes must increase by a factor of 3-4 every 25 years to keep the environmental footprint of the economy from growing.

This is not likely to be achieved by incremental improvements in performance of conventional technologies - a paradigm shift is needed

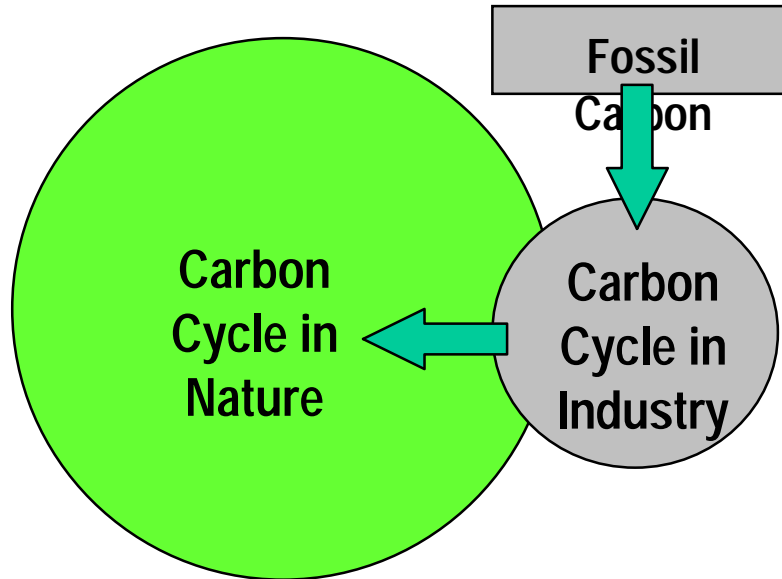
**Eco-efficiency of technology
to keep the environmental footprint of the
economy constant (Minns)**



Assumes annual GDP growth = 4%

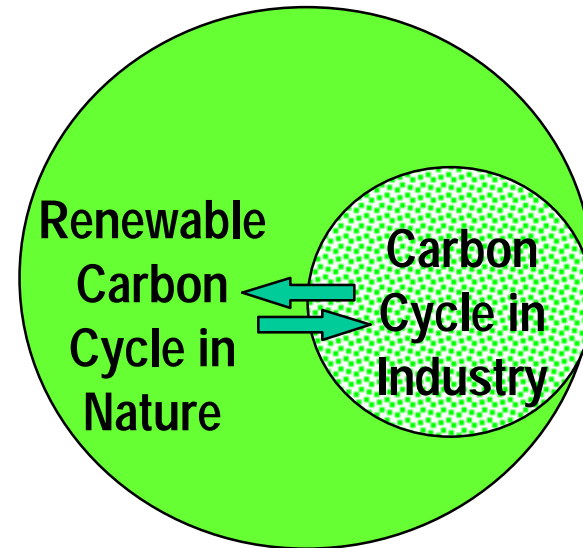
Paradigm shift: changing feedstock from fossil carbon to renewable carbon

**Fossil Carbon Economy -
carbon is used & discarded**



- Waste is a disposal problem
- Growth from increasing production volume

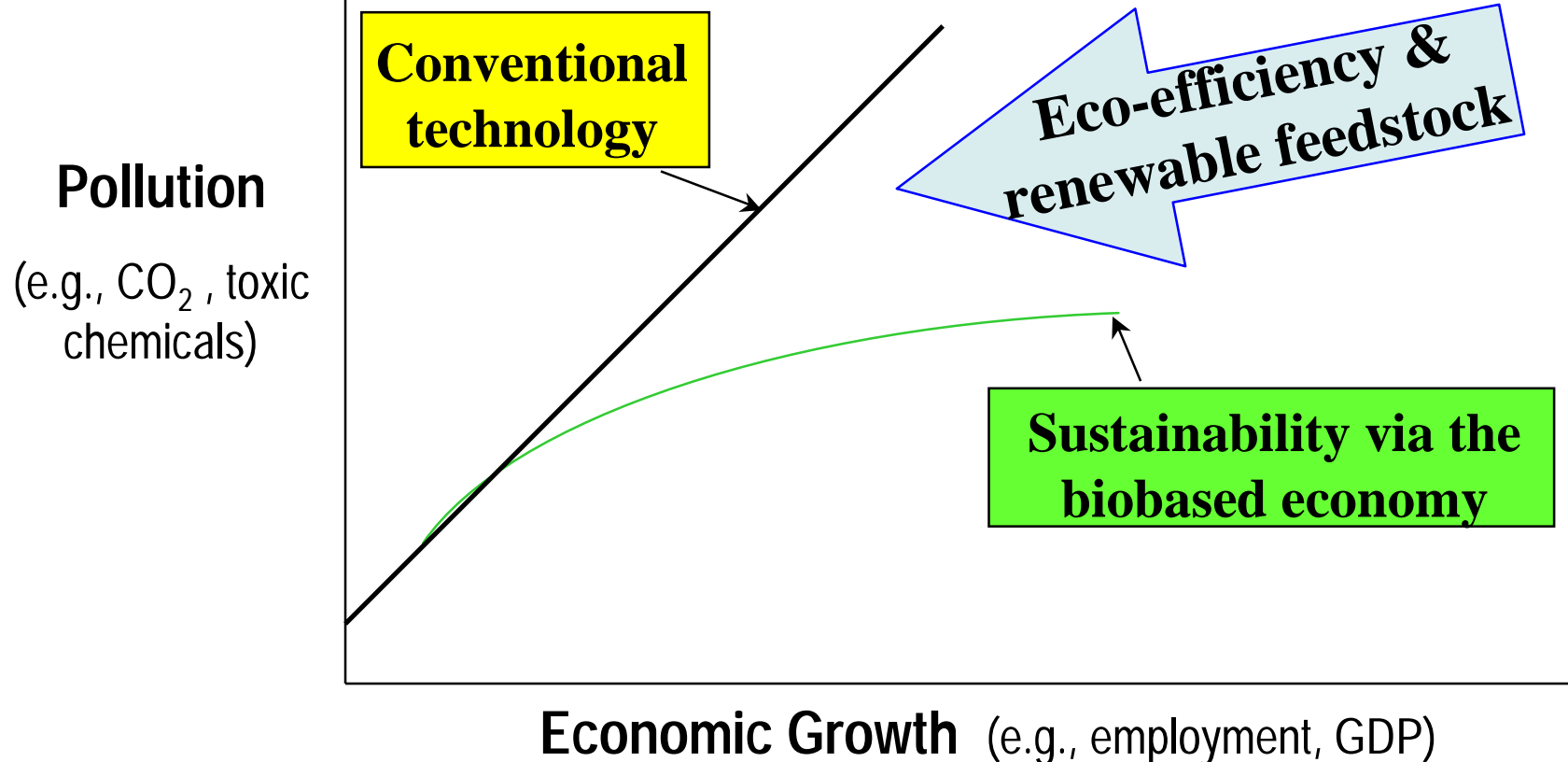
**Biobased Economy -
carbon is recycled**



- Waste is a feedstock opportunity
- Growth from increasing value added

The biobased economy can decouple economic growth from environmental degradation

Historically there has been a direct relationship between economic growth, energy use & environmental degradation



Three Dimensions of Eco-Efficiency

Industrial

- **Process**
 - catalysis vs stoichiometric
 - ambient tem. vs high temp.
- **Feedstock**
 - renewable vs non-renewable
- **Industrial Organization**
 - clusters vs individuals

Biological

- **Bioprocesses**
 - enzyme catalysis
 - fermentation
- **Bioresources**
 - biomass
- **Ecosystems**
 - consortia of organisms

In Nature, bioprocesses have been optimized over millenia to process biological feedstocks

The Biobased Economy

The biobased economy uses:

- renewable bioresources
- eco-efficient bioprocesses and
- eco-industrial clusters

to produce sustainable:

- bioproducts
- jobs and income.

Relevant Industry Sectors

- Energy
- Chemicals & plastics
- Industries that use chemicals & chemical processes
- Forestry; Pulp & Paper
- Mining

In Canada these sectors account for about

- 40% of total industrial energy use
- 60% of total industrial greenhouse gas emissions
- 50% of all industrial pollutants released

Benefits of Industrial Bioprocesses



Findings: simultaneous economic & environmental benefits from increased eco-efficiency

- cost savings 10-50%
- **energy savings 10-80%**
- water savings 20-50%
- pollution & persistent toxic substances greatly reduced

URL: www.oecd.org/biotechnology

Application of Industrial Bioprocesses

- Enormous range of applications
- Ability to evolve for improved performance or entirely new applications
- Scope:
 - natural enzyme > mutation/selection > engineered enzyme
 - organism > simple fermentation > metabolic engineering
 - microbial consortia
 - catalytic surface (e.g. Genencor process for ascorbic acid)

Barriers to Uptake by Industry

- Cost (getting over initial cost hurdle to achieve economy of scale e.g. detergent enzymes)
- Company attitudes & capabilities:
 - Human resources (technical & managerial)
 - Lack of tools & management process to optimize economic & environmental performance simultaneously
- Investor comprehension
- Government policies
 - S&T and HR (need to bridge biology, chemistry & engineering)
 - “un-smart” regulations & regulatory systems
 - trade (barriers to products of biotechnology)

Benchmarks for Acceptance

- When organic chemists regard an enzyme as “just another reagent”
- When whole ranges of enzymes with particular substrate specificities are kept in the laboratory along side other reagents
- When biotransformations are to be found alongside classical organic reactions in key source books and textbooks.

(Quote from Peter Baker, Laboratory of the Government Chemist, London 1992)

Opportunities for Government Leadership

- Direct more biotech & genomics program funding to industrial applications (attract excellent researchers into the field)
- Promote awareness in industry & help develop tools to assess performance
- Support initiatives to inform the investment community
- Support foresight & roadmapping initiatives to encourage industry & research community to set priorities together
- Link roadmapping with regulatory foresight to anticipate novel products & processes
- Support initiatives to inform & engage the public
- Encourage information sharing & cooperation with other countries

Perspective on IEA & OECD Meetings 3-6 March 2003

- IEA March 3-4: scan of issues and driving forces
- OECD March 5: scenarios as a tool to develop public policy relating to the Biobased Economy
- OECD March 6:
 - Framework & Toolkit to Assess Sustainability
 - Measuring bioprocess uptake by industry and effect on performance
 - Organizing to raise the political & public profile of the Biobased Economy internationally