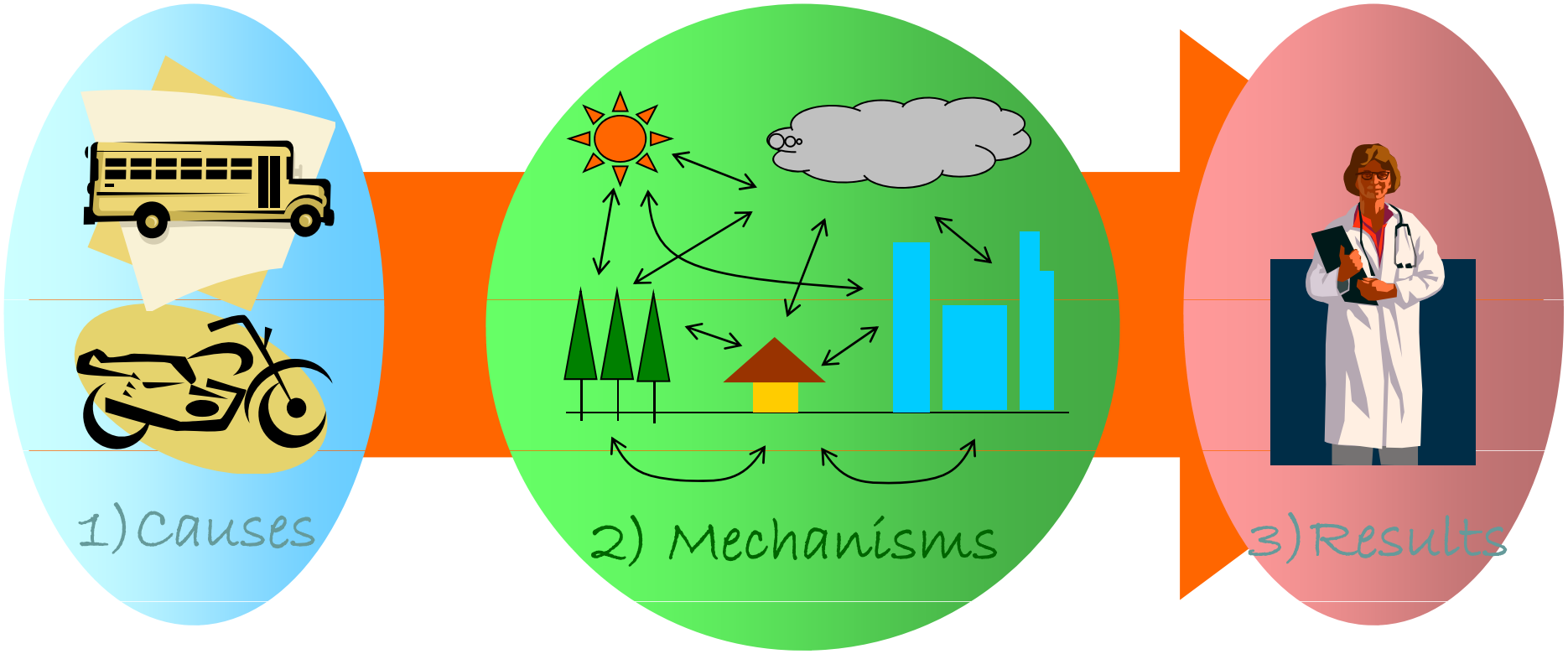
Environmental Impacts of New Technologies

Lecture Material for
“Introductions to Sustainability Science (2011)”

Prof. Yasuhiro Fukushima,
Department of Environmental Engineering, NCKU

What is an Environmental Issues/Impacts ?

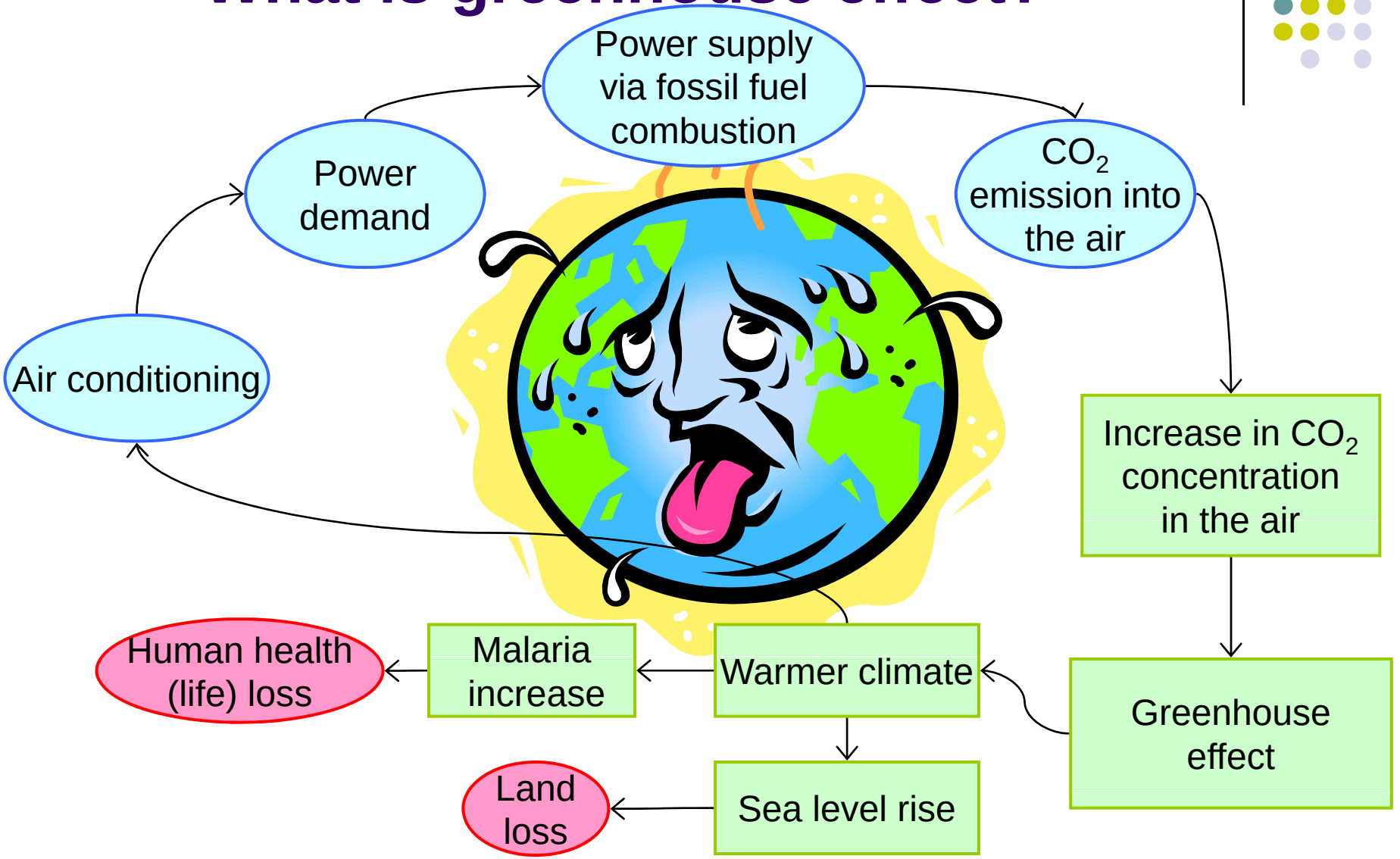


Caused by human activities

Physical & Ecological environment lies between causes and results

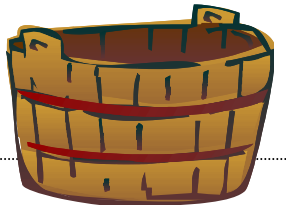
Affects human activities

What is Global Warming?
What is greenhouse effect?



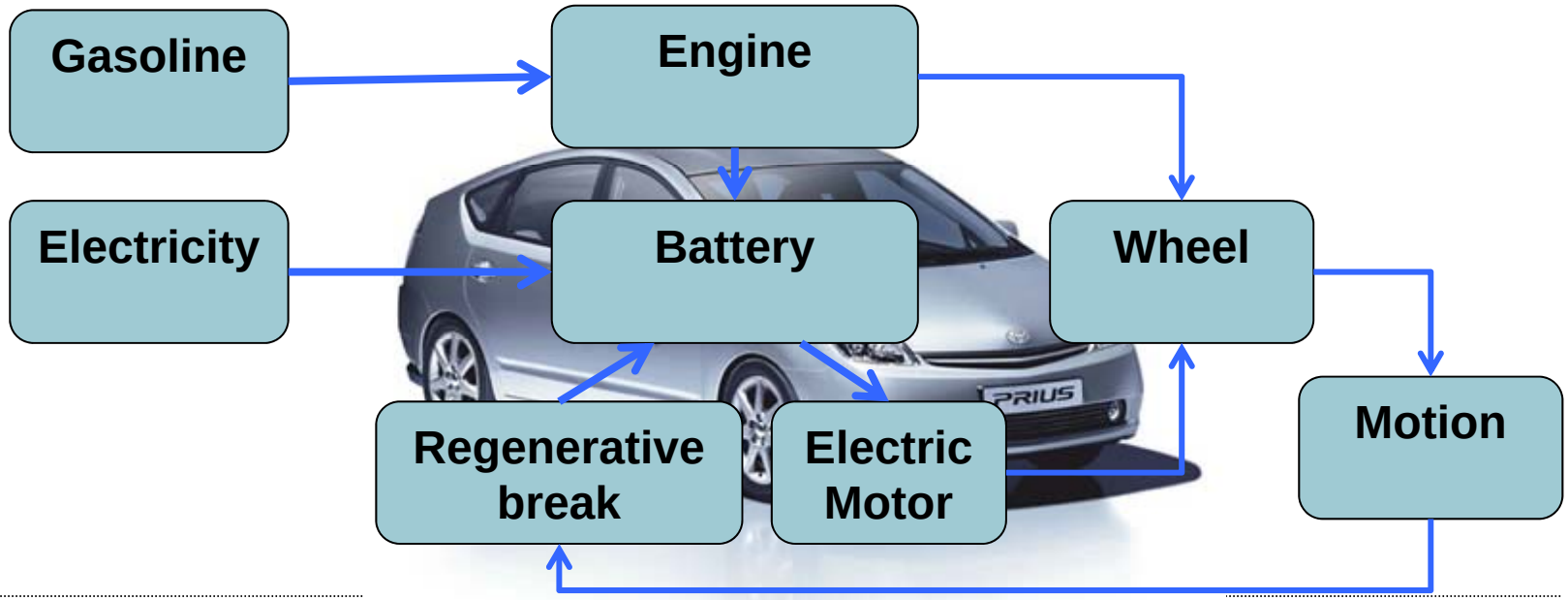
Consequences…

- **「風が吹けば桶屋が儲かる」**
  If the wind brows, then tub producers will make more money.
  (Japanese traditional comic story telling, 落語(rakugo))
  - Spring wind brows
  - Sand dust blown up
  - Sand dust hurts people's eyes
  - Cause eye disease
  - People play *shamisen* (string instrument that use cat skin on its body) and make a living
  - less cats
  - more mice
  - people use tub to catch mice, but mice would make a hole on tubs and run away
  - people need to ask tub producers to fix their tub
  - tub producers will make money



Consequences of innovations of a new technology

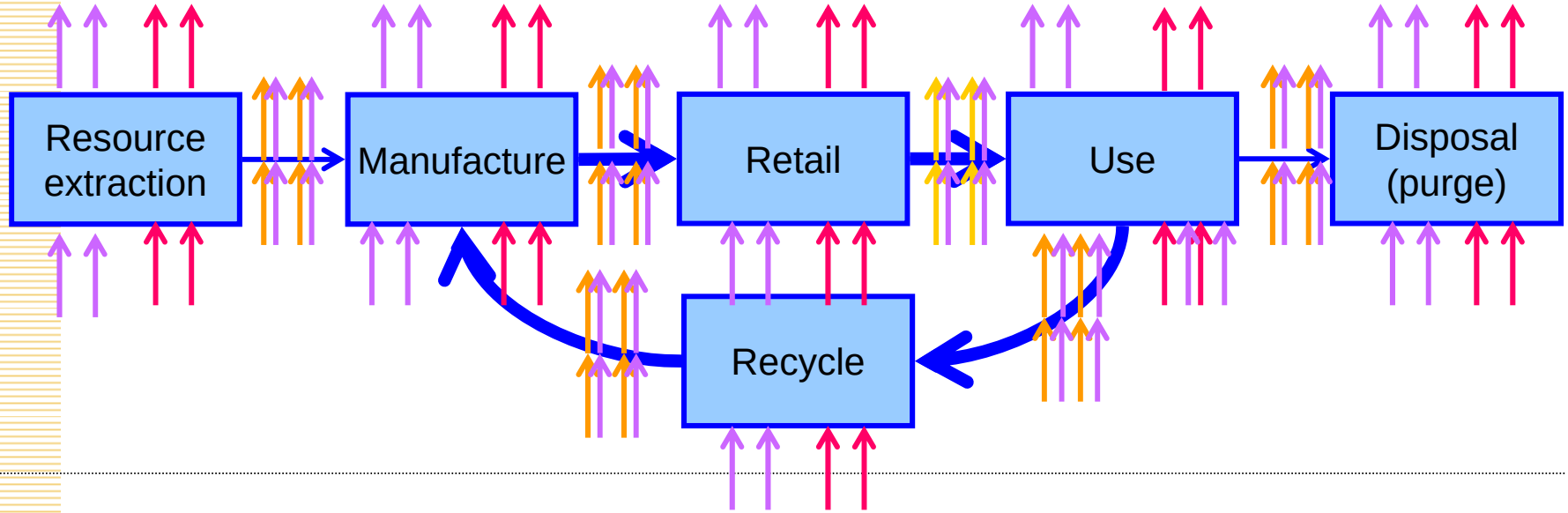
- **Hybrid vehicles** realizes a significant improvement in the travel distance per liter of fuel. What are the consequences of introduction of this product into the market?



Life Cycle Assessment (LCA): An Environmental Systems Analysis tool

- Calculates environmental impact *associated with* a product (i.e. goods and service)

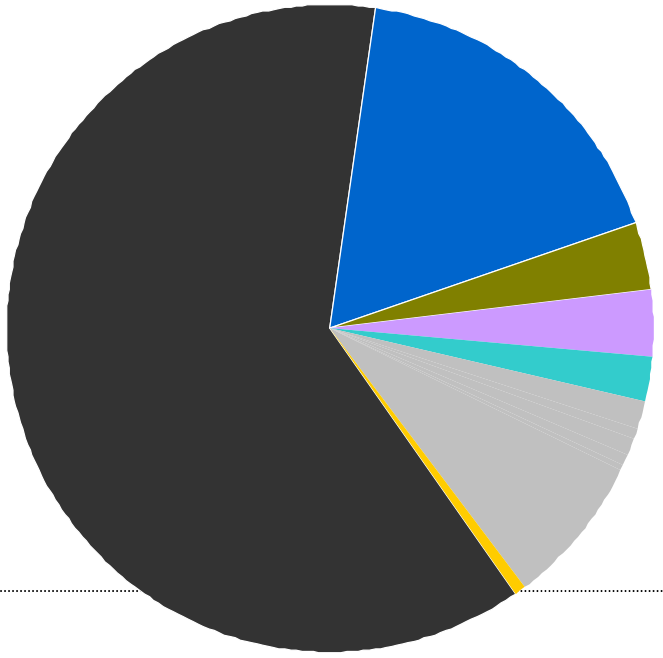
- **Life cycle thinking** (Life cycle approach)
  - Take into account of entire **life cycle** of products in systems analysis, design, and decisions



Typical results

A tool to quantitatively analyze environmental impacts associated with a product.

- Product: Goods or Service
- Association: Product life cycle (cradle-to-grave)



Benefits from LCA

- Better understand where the product comes from and where it goes
- Understand where important environmental interventions occur
- Identify improvement opportunities
- Communicate importance of appropriate consumption
- Evaluate solutions without overlooking important items

LCA takes “Domino approach”

- **Domino effect:** The domino effect is a chain reaction that occurs when a small change causes a similar change nearby, which then will cause another similar change, and so on in linear sequence.

- **Butterfly effect:** The phrase refers to the idea that a butterfly's wings might create tiny changes in the atmosphere (in Brazil) that may ultimately alter the path of a tornado or delay, accelerate or even prevent the occurrence of a tornado in a certain location (in Texas).

Rebound effects

- **A behavioral or other systematic response to the introduction of some measures that save resources, that offset the benefits.**
  - Measures: New technologies, policies, business models, etc.
  - Resources: money, time, energy, ...

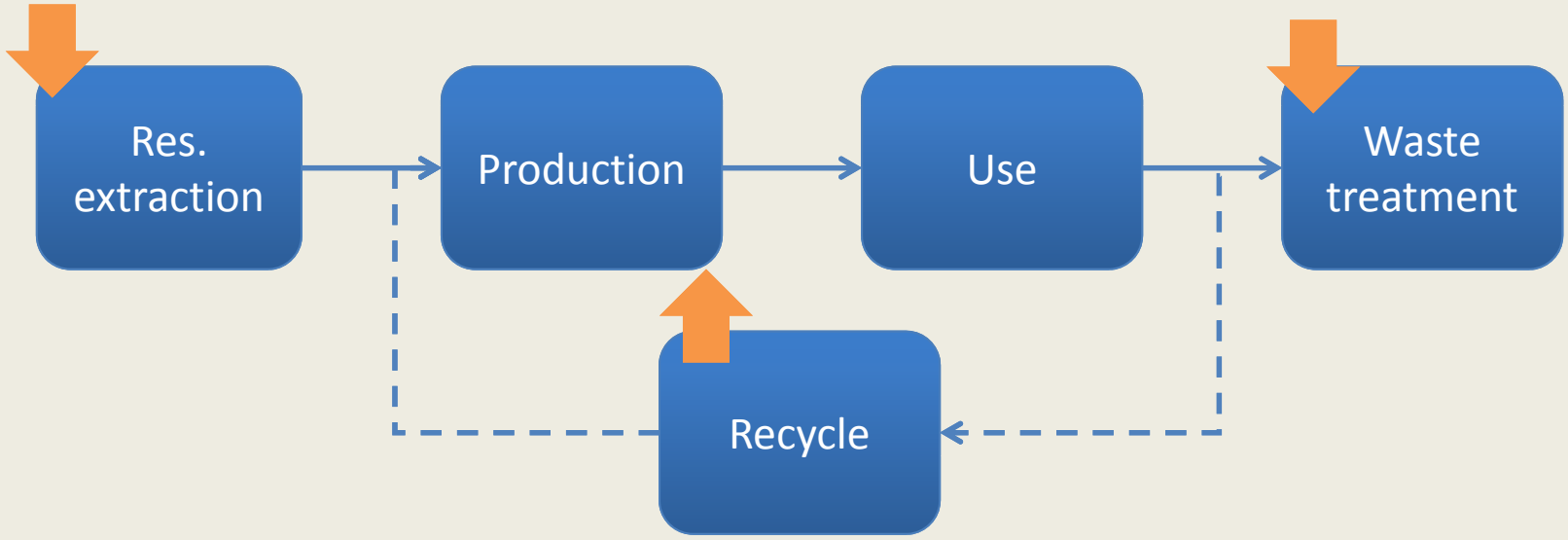
The saved resource can be used in resource consuming actions

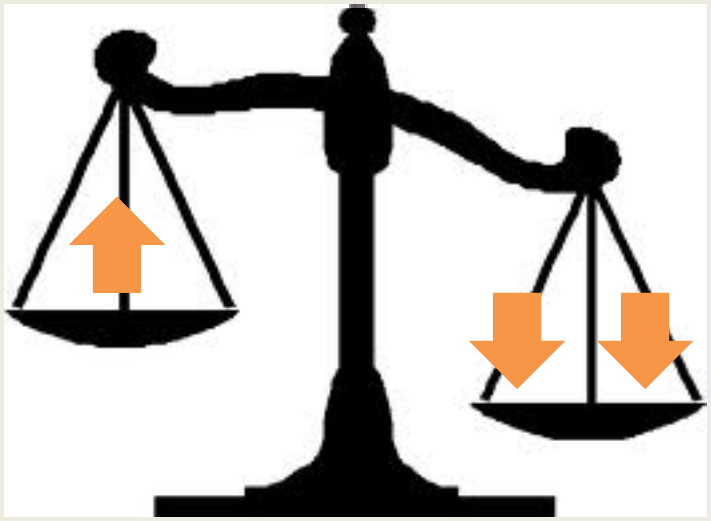
Reference:
Edgar G. Herwitch (2005), Consumption and the Rebound Effect, Journal of Industrial Ecology(9), No.1-2, P.P. 85-98.

Other effects

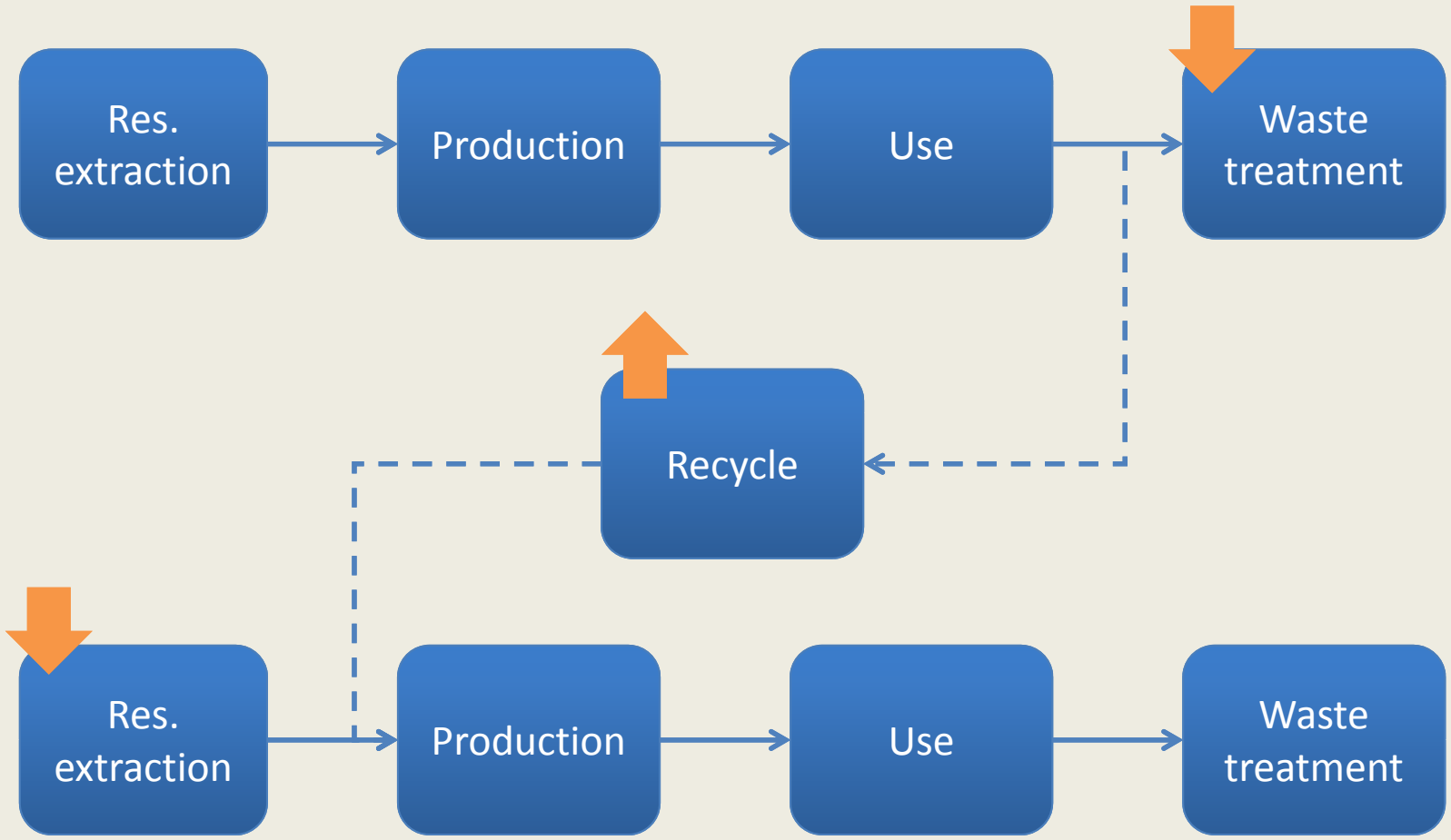
- **PET bottle recycling technologies in Japan**
  - **Reuse of bottle is prohibited**
    (not the same in some countries: Thai, Philippines, Germany, Austria, Belgium, Hungary, Netherlands, Sweden, Norway, Czech, Denmark, Switzerland)
  - **Post consumer PET bottles can be recycled with material recycling, and chemical recycling**
    - Material recycling
      - wash, chop into flake, melt, use (fiber, sheets)
      - smaller loop → less energy for recovery
    - Chemical recycling
      - depolymerized, chemically purified and reused for any purposes (incl. bottles)
      - green bottles, dirty bottles are not a problem in this method

Evaluation of recycling using LCA

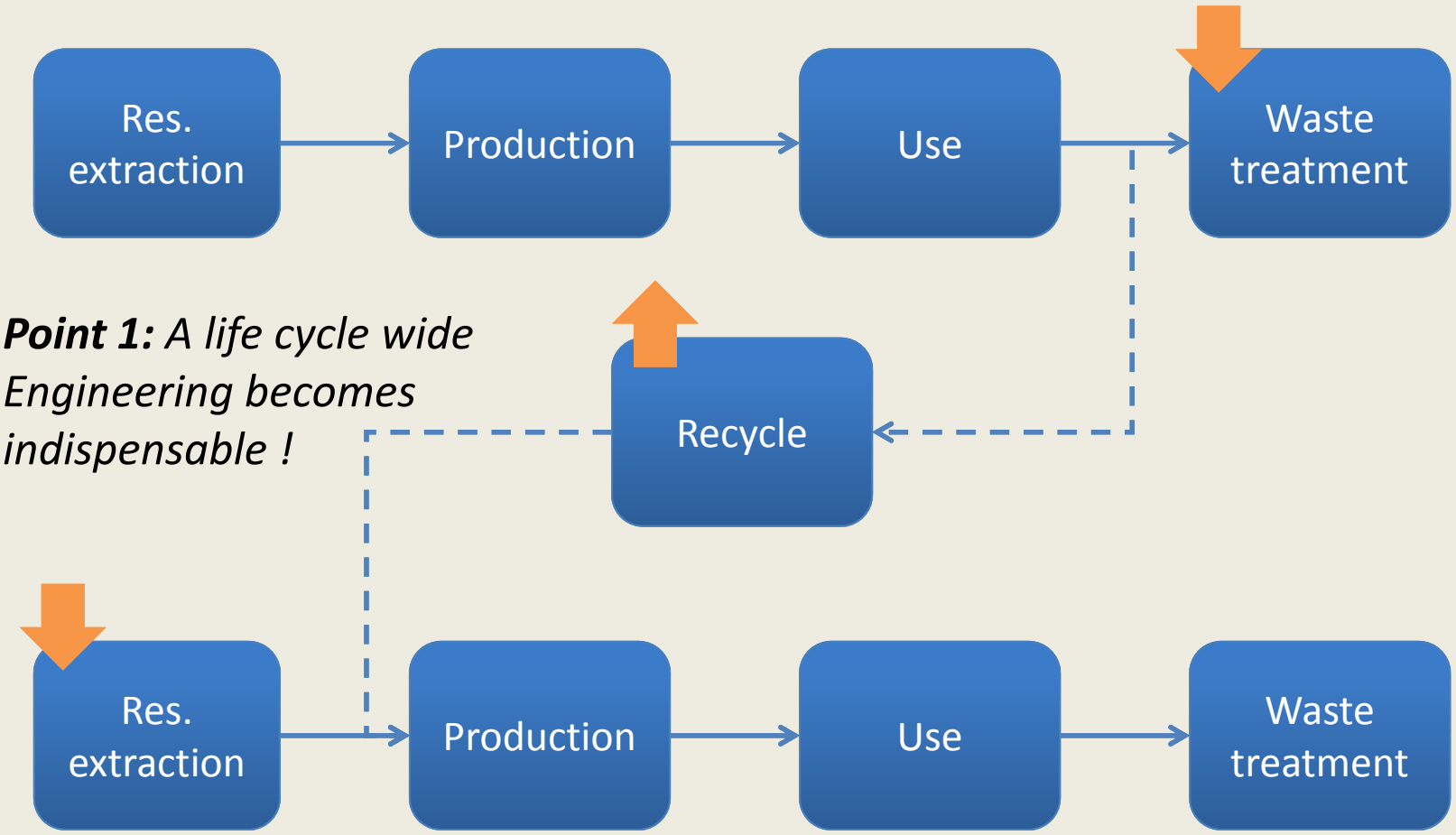




Evaluation of recycling using LCA



Evaluation of recycling using LCA



Point 1: *A life cycle wide Engineering becomes indispensable !*

Point 2: *Does recycled material actually avoid consumption of materials ?*

Influenced Industries

- Recycled resin is provided to mainly fiber and sheet industry





Men's suits = 3 PET bottles

Quality interference by recycling

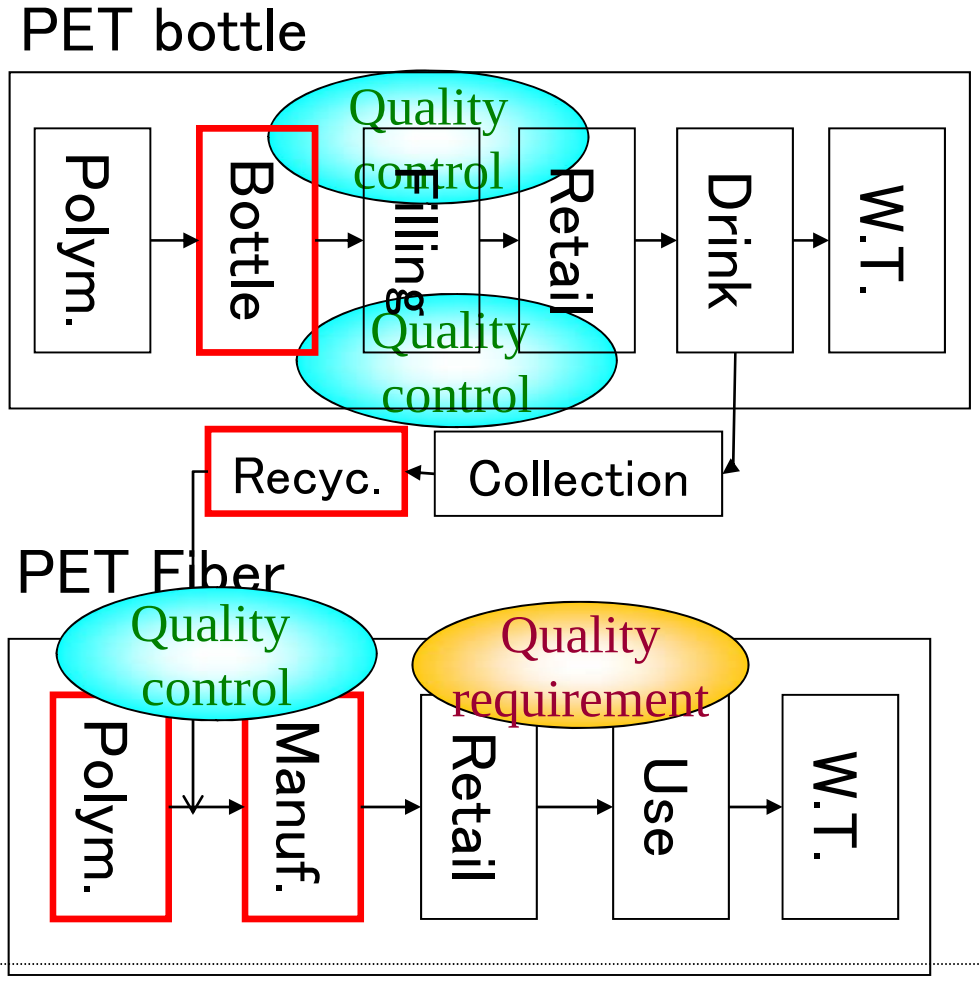
- **Fiber industry is a high quality industry**
  - sophisticated fiber mechanisms (ex. nano-fibers)
    - touch, breath, coloration, water absorption / shedding…
  - 1 roll → more than **4km** without broken thread

- **Use of recycled PET resin will increase troubles in the fiber industry**
  - increased maintenance (ex. changing filter)
  - more frequent broken thread (lower yield)

Sector level quality and cost agreement / management is required for achieving success with open-loop recycling systems!

Spread of quality control points

- Cascading life cycles make quality management scope expand!!



New Product: Consequences?

Life cycle? Rebound effect? Quality interference? Others?

しぼれる1020ml PET登場!

1 しぼれる
520ml同様に、
簡単にしぼってつぶせる
18gパッケージ。

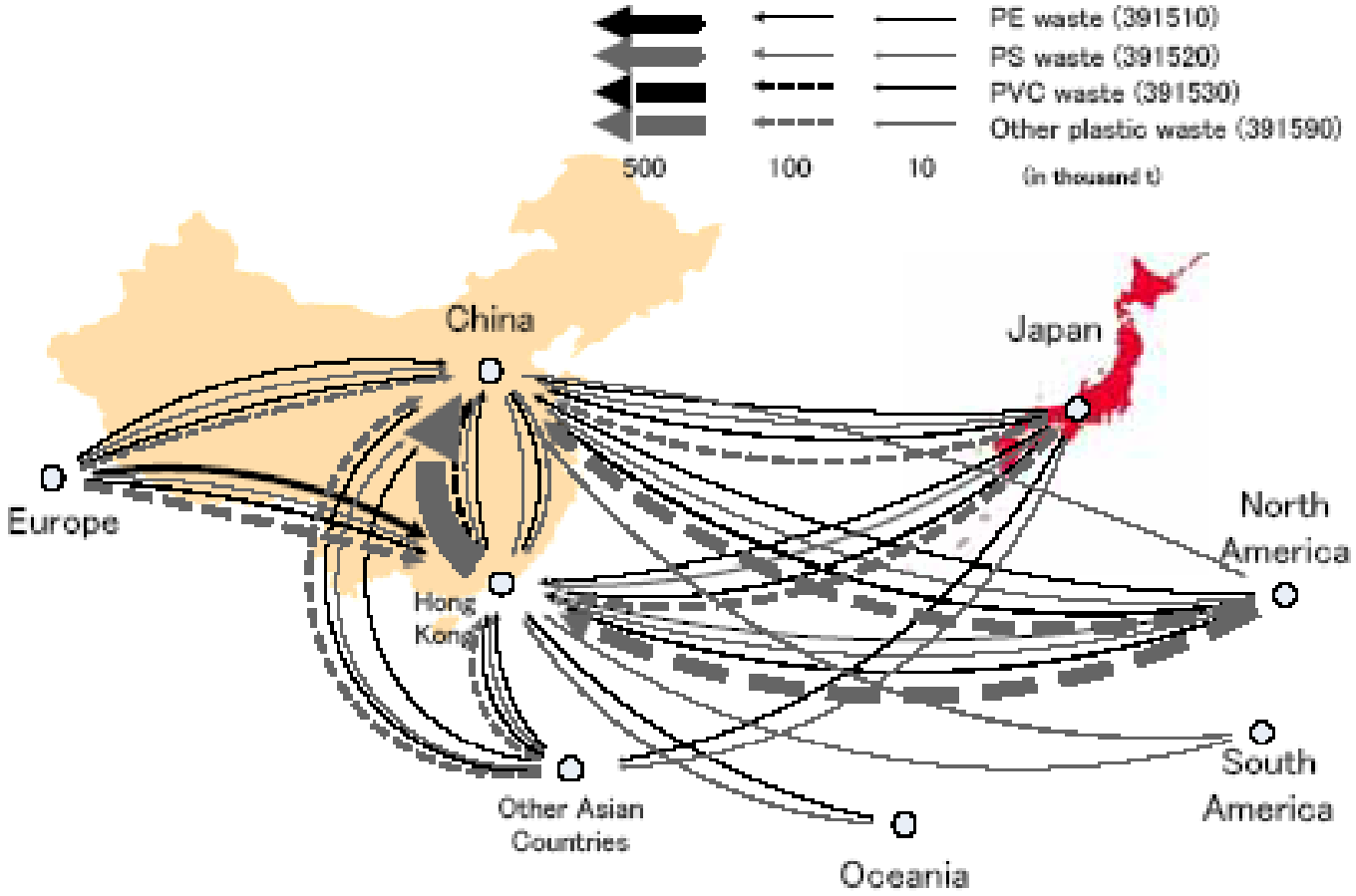
2 1020ml
コンパクトなのに
20ml多い。

3 プラントボトル
植物由来素材を
一部（5—30%）
使用したボトル。

plantbottle

Recycling Industry is also globalized !!

- Post-consumer plastics go to China…



Is it legal? Isn't there any problems?

Materials come back home…

- How do they come back?

Summary

- **To avoid unexpected increase in problems, we need to systematically understand consequences of introduction of technologies**
  - Life cycle thinking provides comprehensive views on product systems
  - Rebound effects provide (parts of) behavioral implications
  - Recycling could some times create unnecessary products
  - Product design needs considerations on recycling and the second product life cycle