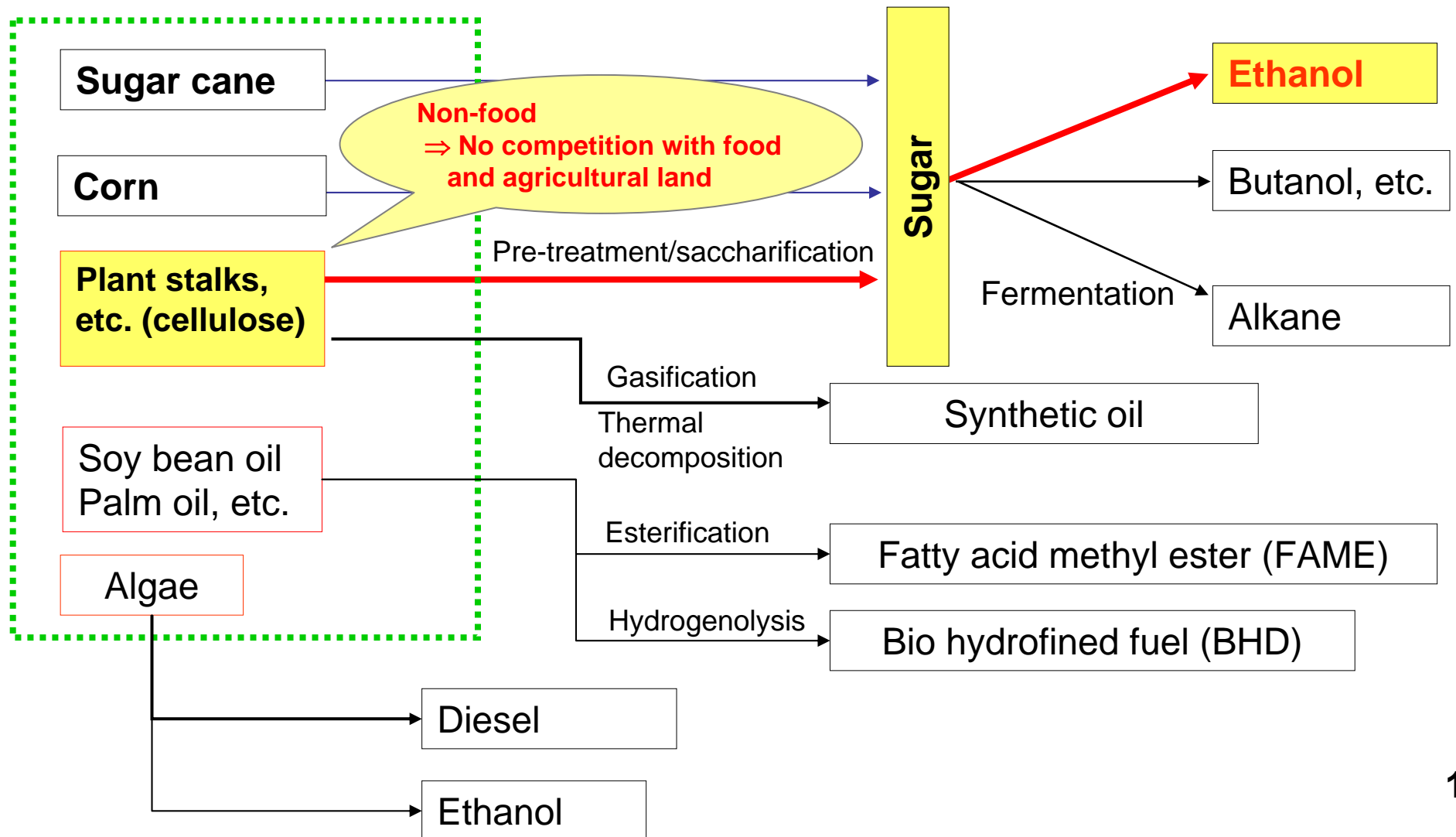


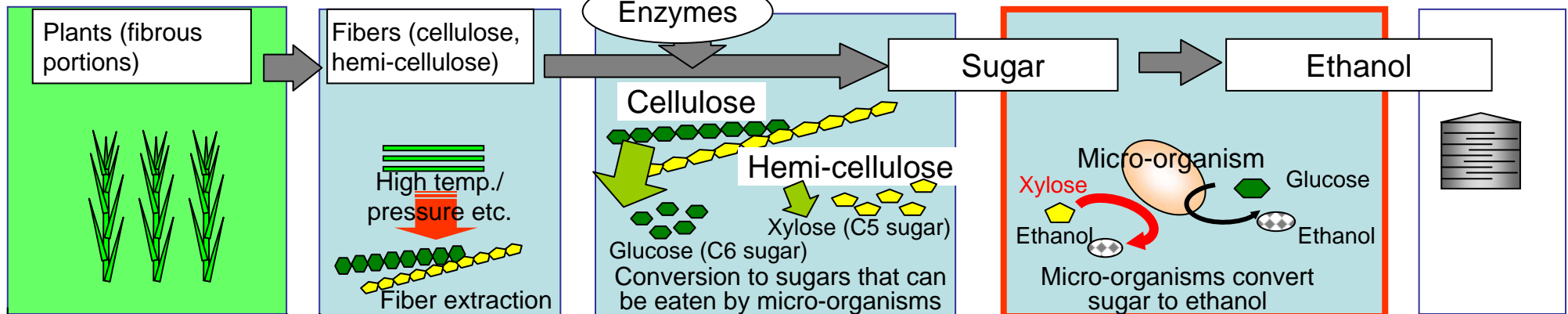
Details of Bio-Fuels (Cellulosic Ethanol)

Bio-fuel based on non-Food \Rightarrow cellulosic ethanol



Bio-Fuel: Cellulosic Ethanol Production Process

(1) Raw materials (2) Pre-treatment (3) Saccharification (4) Fermentation (5) Refining



Aim: accelerate spread of bio-fuels by greatly reducing cost of cellulosic ethanol production process

Issue 1: Stable supply of raw materials

- (1) Effect on food price and supply
- (2) Cost and sustainability

Issue 2: Reducing production costs

- (1) Improving yield
- (2) Reducing cost of equipment and sub-materials

3F laboratories

- Member of The Research Association of Innovative Bioethanol and carries out consigned research from the New Energy and Industrial Technology Development Organization (NEDO)

- Bacteria/process development: In-house and at Toyota Central R&D Labs., Inc.

- Practical production technology and know-how: Research consigned from NEDO (Kyoto University, Tottori University, Japan Chemical Engineering & Machinery Co, Ltd.)

1F laboratories

Issue 1: Stable Supply of Raw Materials

Raw materials

Pre-treatment

Saccharification

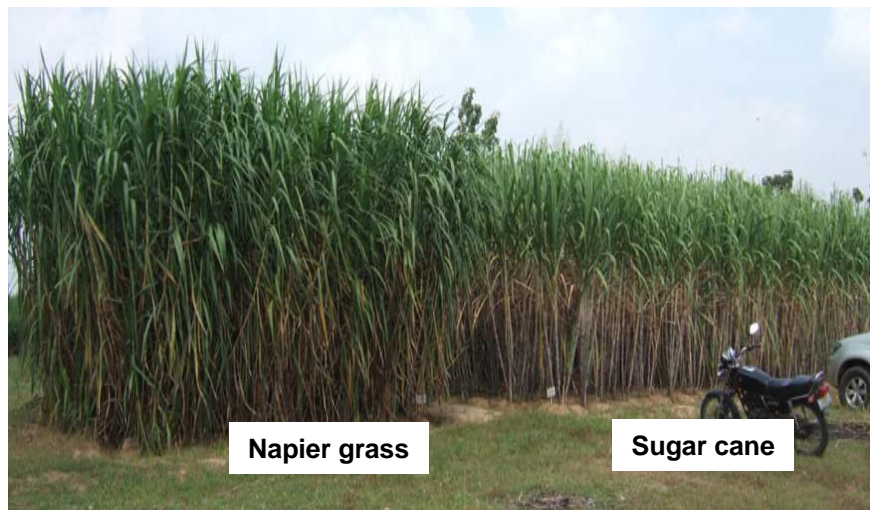
Fermentation

Refining

Cultivation trials are underway in Indonesia on land unsuitable for growing crops, with the aim of establishing a cheap and sustainable method of producing raw materials for bio-fuels. Napier grass is a promising candidate due to its high growth rate and low cultivation cost.

Issue 1: Stable supply of raw materials

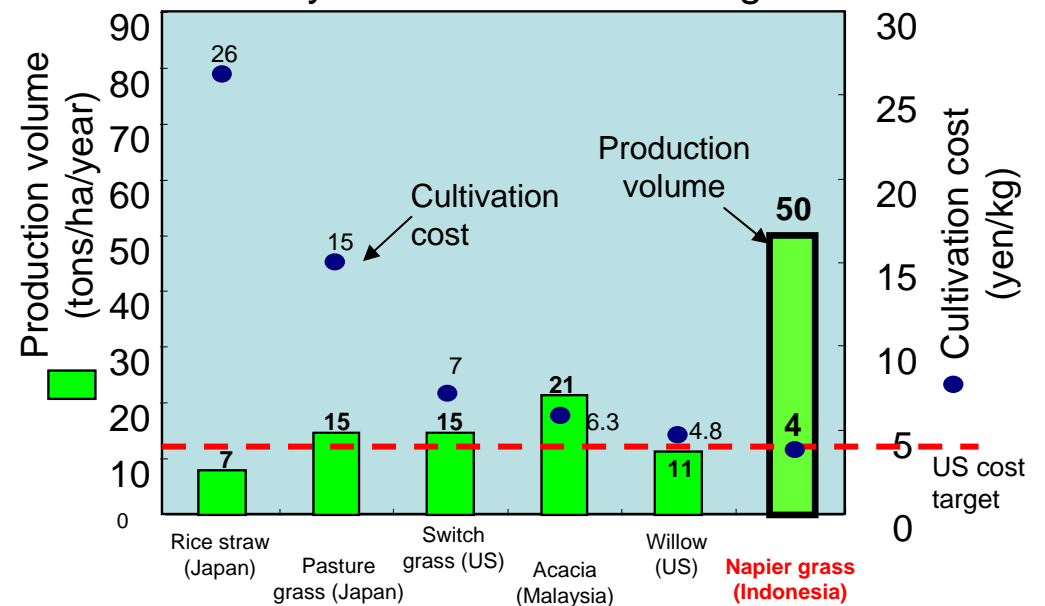
- (1) Effect on food price and supply
- (2) Cost and sustainability



(Consigned from NEDO)

2. Countermeasures

- ⇒ Secure site for large-scale cultivation of plants that can be grown on land unsuitable for crops.
- ⇒ Select plants and cultivation method with high production volume per unit area and create cultivation system that does not degrade soil.



Issue 1: Stable Supply of Raw Materials

Raw materials

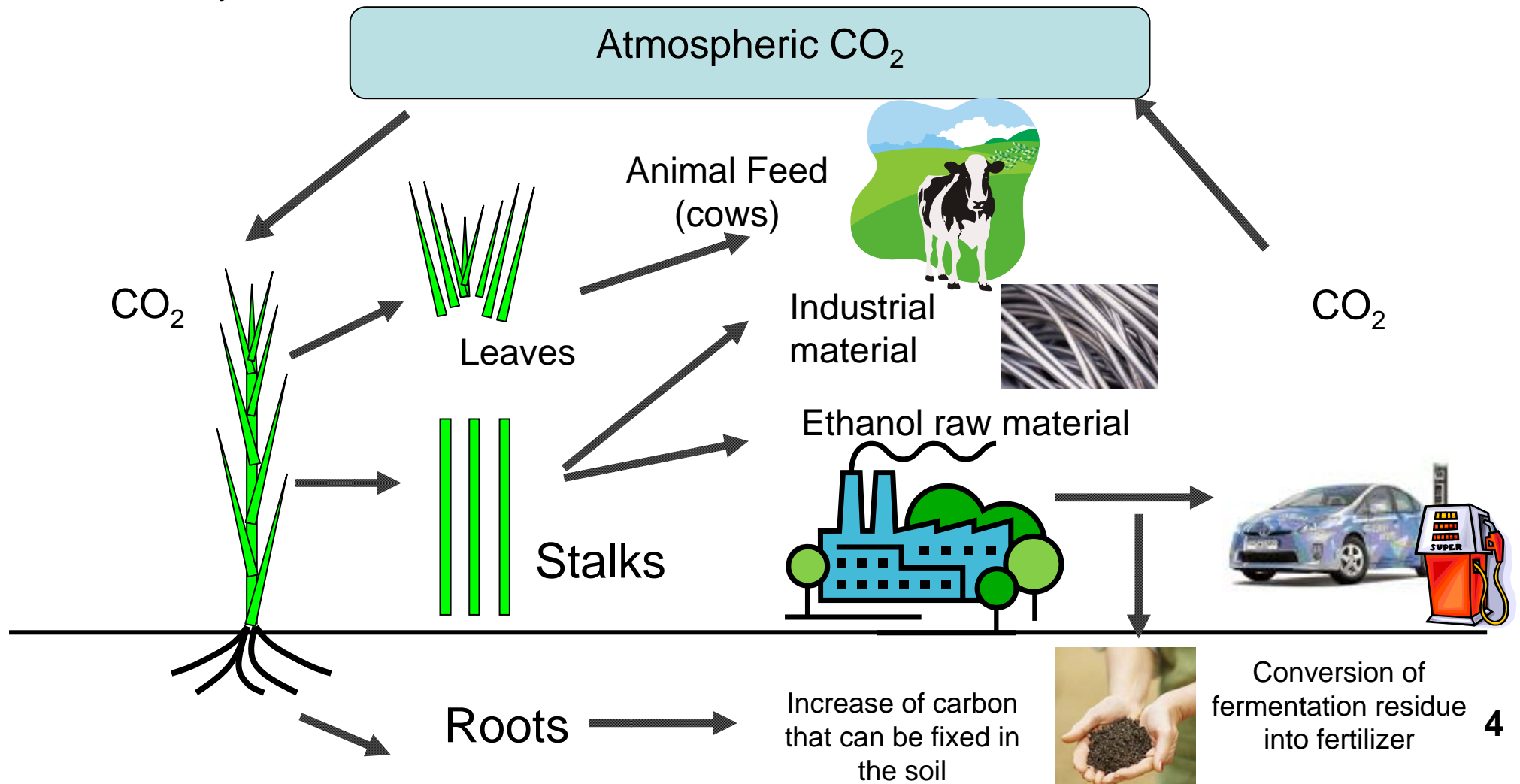
Pre-treatment

Saccharification

Fermentation

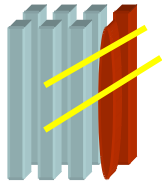
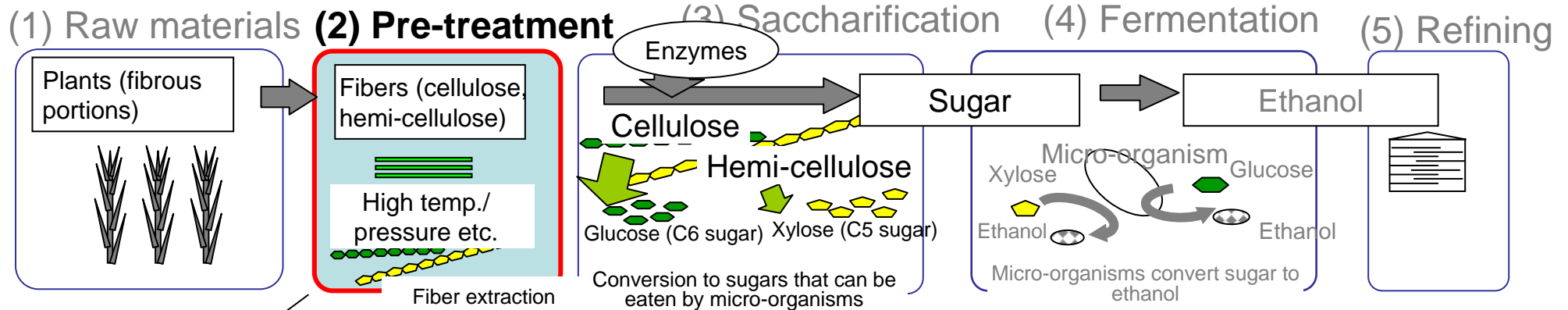
Refining

A system is being constructed that considers the various usages of Napier grass and the sustainability of the soil.



Issue 2: Reducing Production Costs (Pre-Treatment)

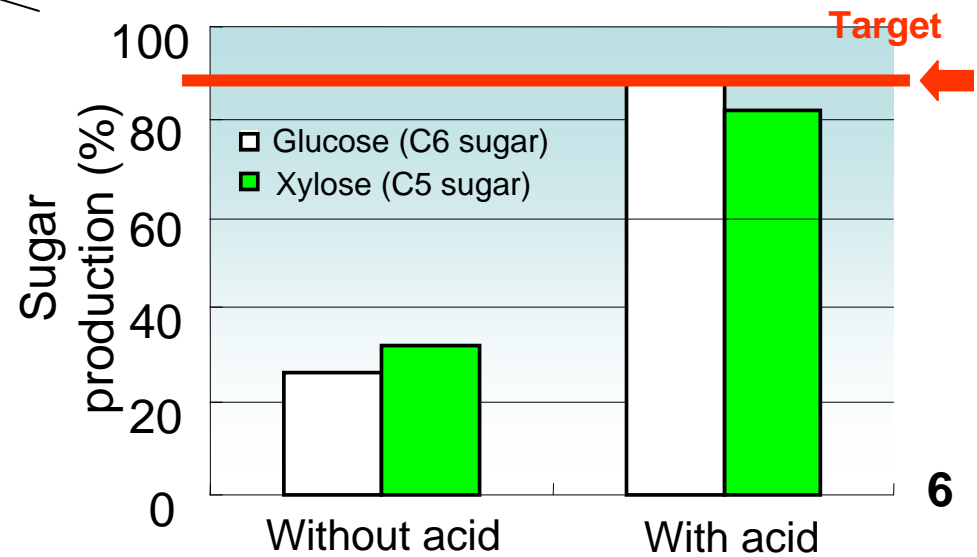
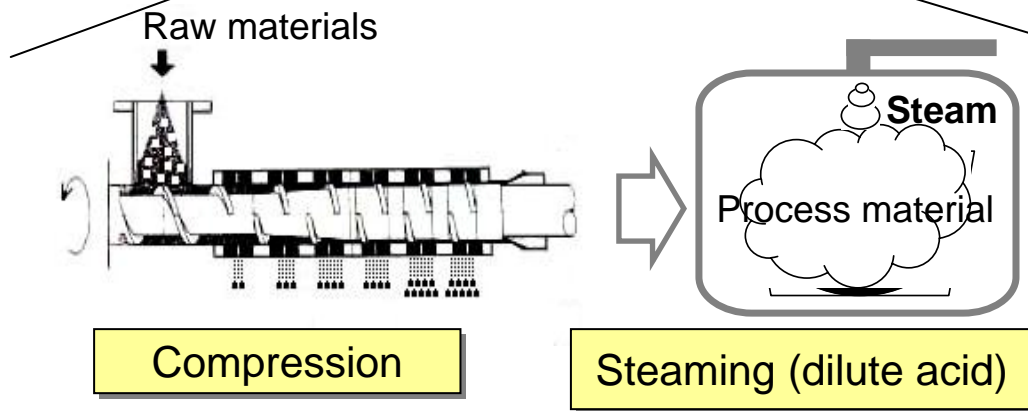
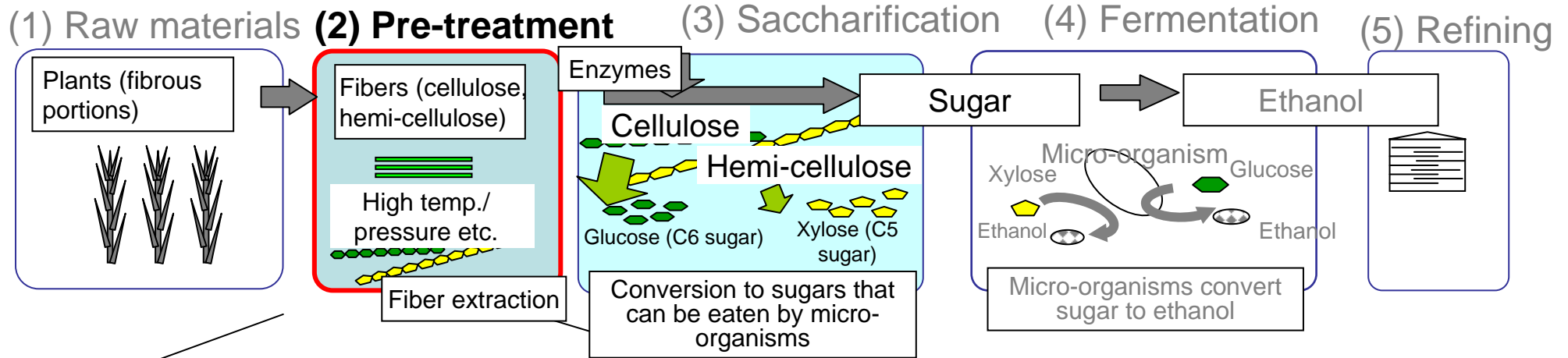
Evaluation of various pre-treatment methods



	Mechanical Crush Pulverization	Break up crystal structure Ammonia process Ionic liquid	Hemi-cellulose dissolution Steam treatment (acid.etc)	Change lignin structure Ammonia process Alkali process	Lignin removal
Input energy	High ✗	High to medium ✗	Medium	High ✗ (Re-use of ammonia)	
Equipment cost	Medium	Medium	Medium	High ✗	
Fermentation inhibitor	Medium	Low amount ○	Large amount ✗	Low amount ○	
Other		Reagents ✗	Waste processing ✗	Reagents ✗	

Issue 2: Reducing Production Costs (Pre-Treatment)

Establishment of a simple combined crushing and steaming process, and optimization of conditions

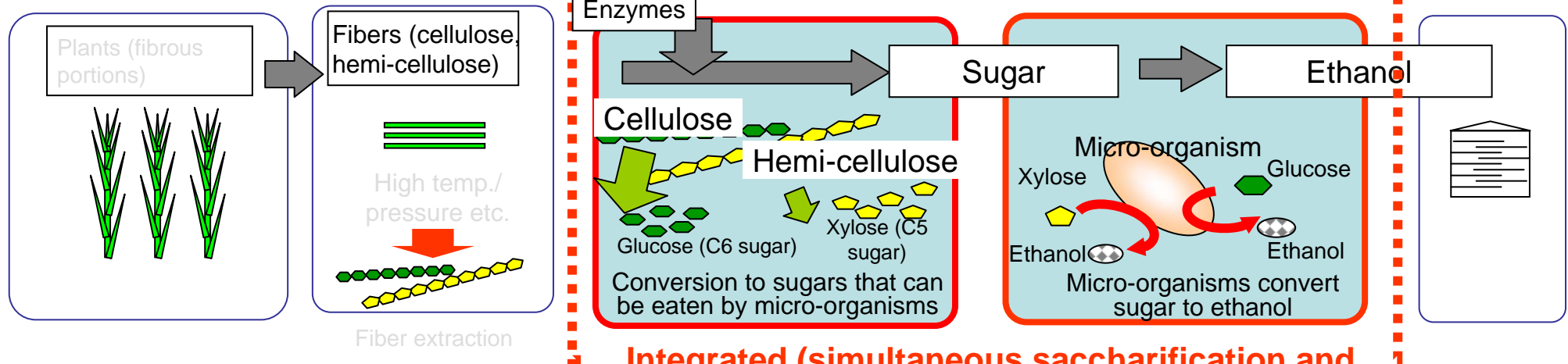


Issue 2: Reducing Production Costs (Saccharification and Fermentation)

Establishment of a simple integrated saccharification and Fermentation process and optimization of conditions



(1) Raw materials (2) Pre-treatment (3) Saccharification (4) Fermentation (5) Refining



Integrated (simultaneous saccharification and fermentation)

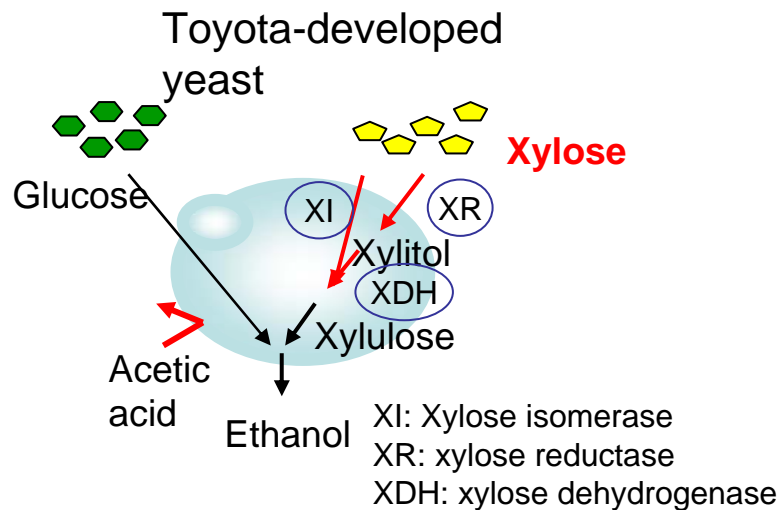
⇒ Reduce equipment costs and improve yield

Development item 1:

Integration of saccharification and fermentation
 Identification of optimum conditions for saccharification enzyme and yeast

Development item 2:

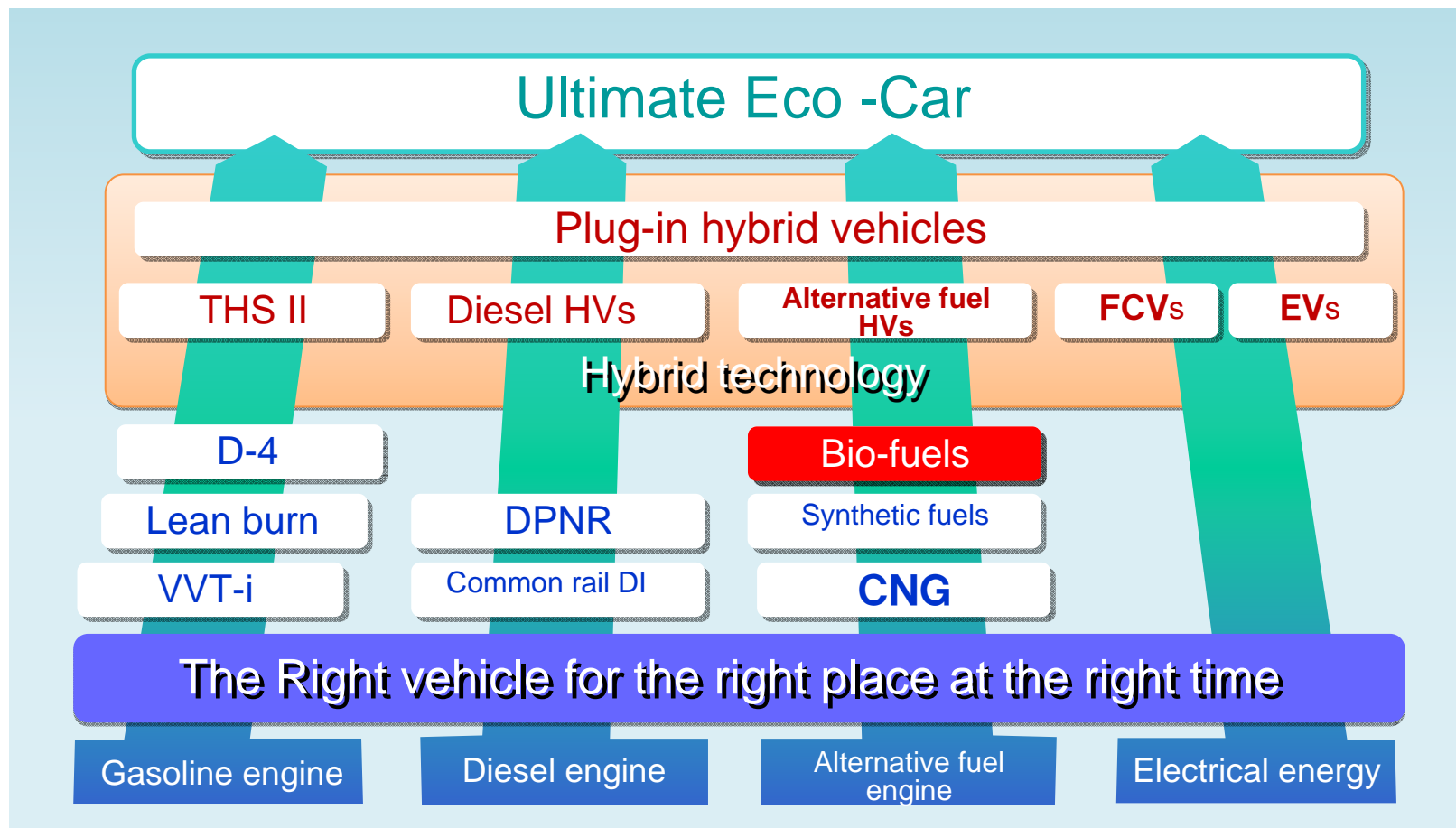
Development of new bacteria which can eat xylose with resistance to fermentation inhibitors such as acetic acid, etc. **7**



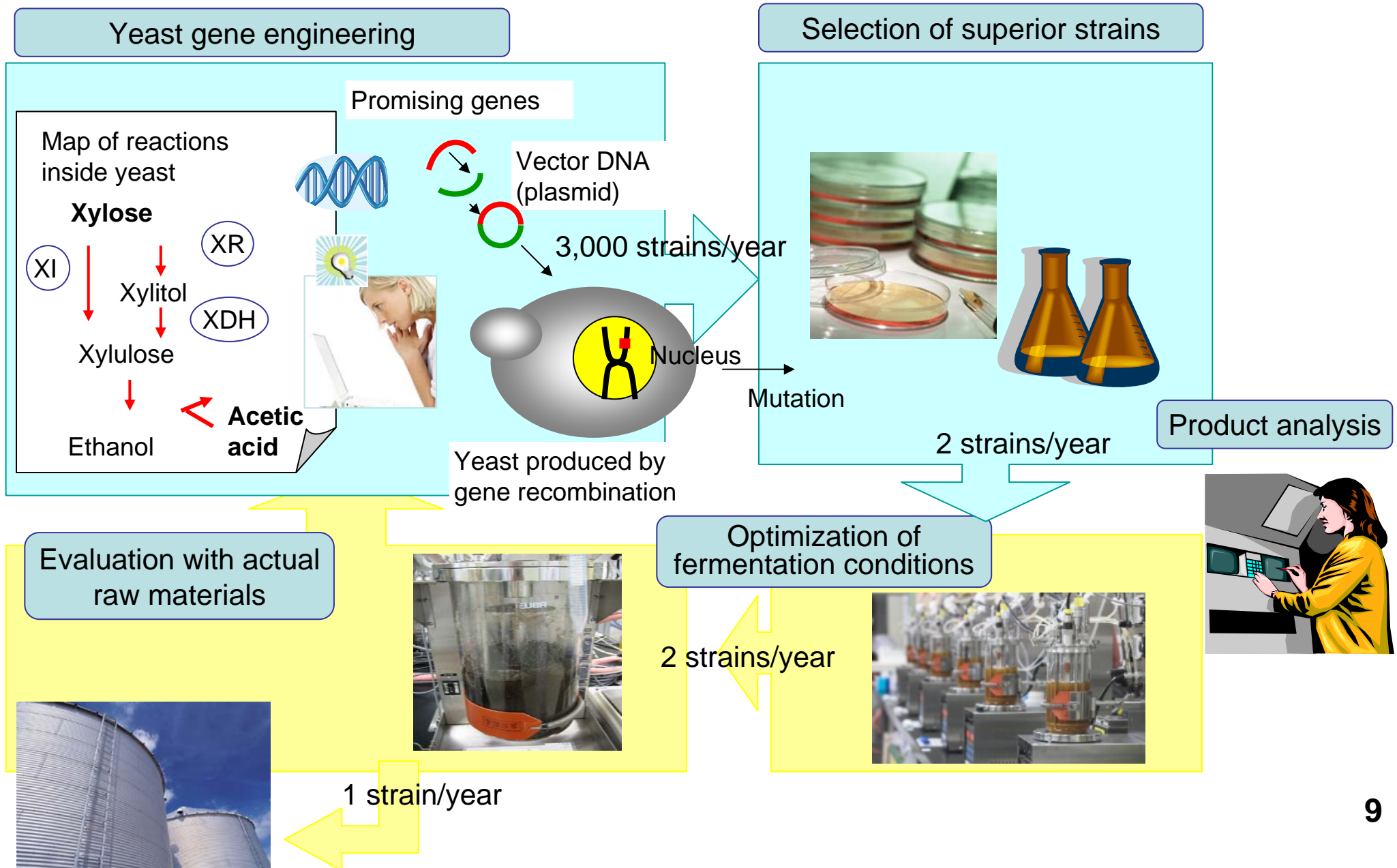
Future Technological Development at Toyota

Open Innovation

- ✓ In addition to further refining Toyota's yeast technology, we are making progress in verification by improving the production processes.
- ✓ In the medium to long term, we will promote the spread of renewable fuels in cooperation with energy companies and the like.



Yeast Development Procedure

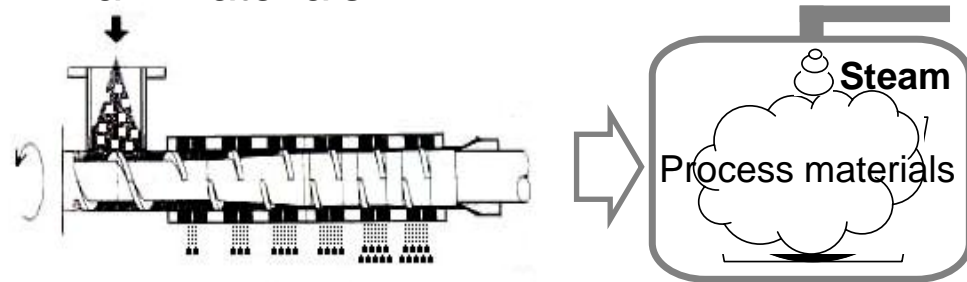


Evaluation of Toyota's yeast by Full Process Test



World class ethanol productivity by Toyota's new yeast using Napier grass samples.

Raw materials



Compression

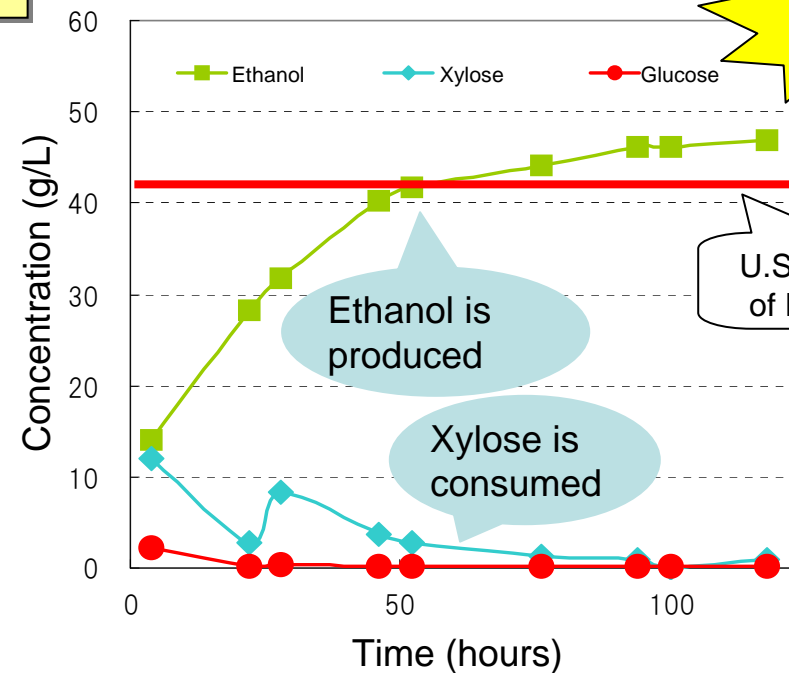
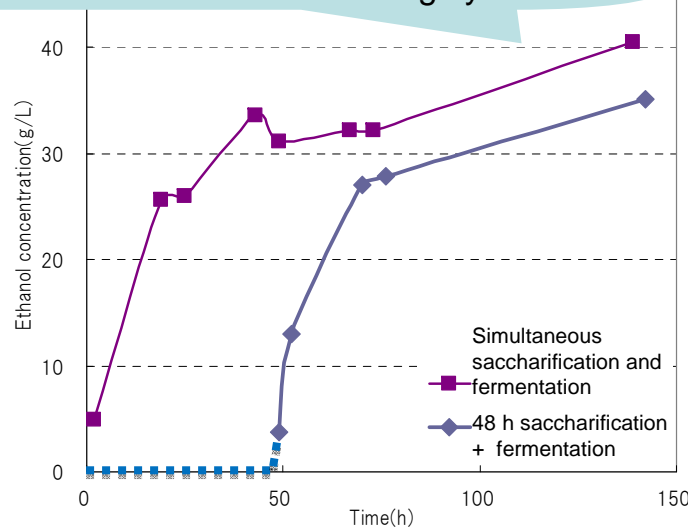
Steaming (dilute acid)



- 150 g/L Napier grass pre-treatment sample

87% of raw material sugar used

The saccharification ⇒ fermentation process reduces equipment costs and simultaneous saccharification and fermentation is highly efficient.



U.S. Department of Energy: 84%

Mini-Plant Outline

Technology is being developed to achieve practical application of the saccharification and fermentation plant (joint development with Kyoto University, Tottori University, and Japan Chemical Engineering & Machinery Co, Ltd.).

