



Pretreatment/Saccharification of Red Algae for the Production of Bioethanol

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*Special Symposium on R&D for Marine
Bioenergy*

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Prediction & Prospect

Peak Oil

- M. King Hubbert -

Wake up!!!



Peak Oil

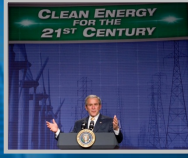
is the point or timeframe at which the maximum global **Petroleum Production** rate is reached. After this timeframe, the rate of production will enter terminal decline

Agflation (agriculture+inflation)

While we worry about gas prices, the cost of milk, meat and fresh produce silently skyrocket

- Victor Davis Hanson -

Twenty In Ten




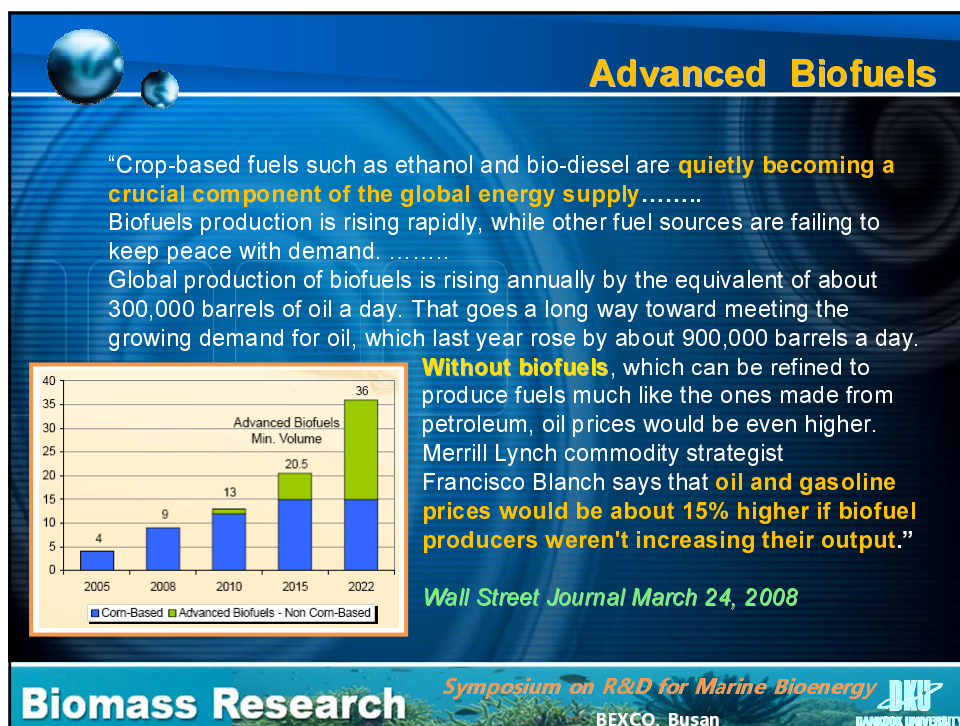
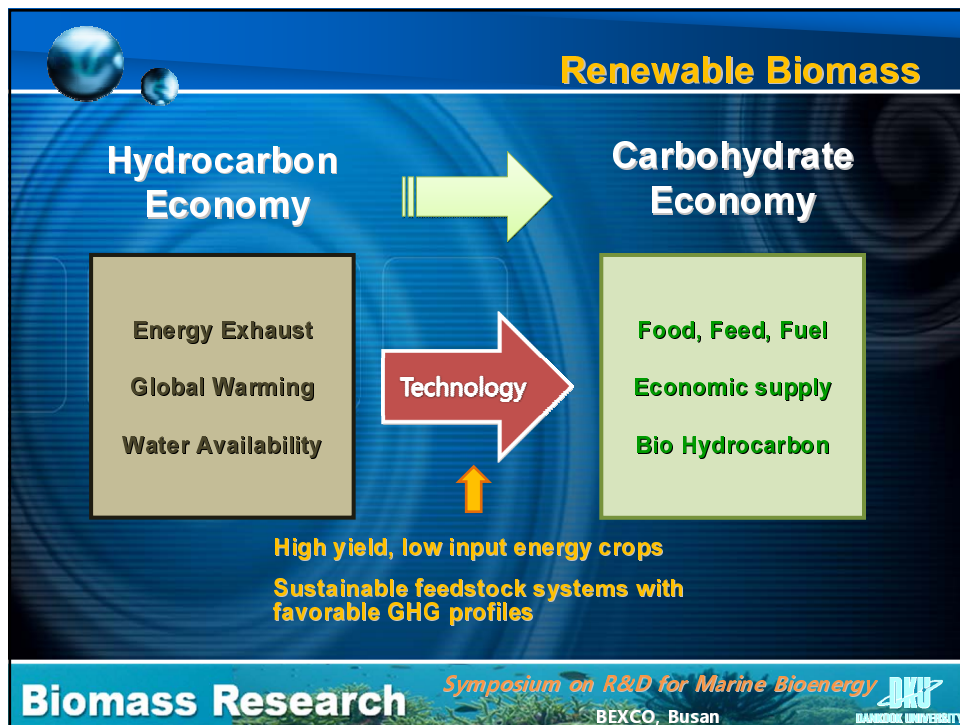
Goal To Cut U.S. Gasoline Consumption By **20 Percent** Over The Next **Ten Years**

State of the Union Address, 2007


... We'll also fund additional research in cutting-edge methods of producing ethanol, **not just from corn, but from wood chips and stalks, or switch grass.** Our goal is to make this new kind of ethanol practical and competitive **within six years**

State of the Union Address, 2006

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Biofuels Timeline




2007

- 2012** Cost-competitive cellulosic ethanol
- 2015** U.S. transportation fuels contain at least 3 billion gallons of cellulosic biofuels**
- 2022** U.S. transportation fuels contain at least 16 billion gallons cellulosic biofuels**
- 2030** Displace 30% of U.S. gasoline consumption*
Ramp up the production of biofuels to 60 billion gallons

US DOE Biomass Program, 2008



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EISA 2007: New Targets




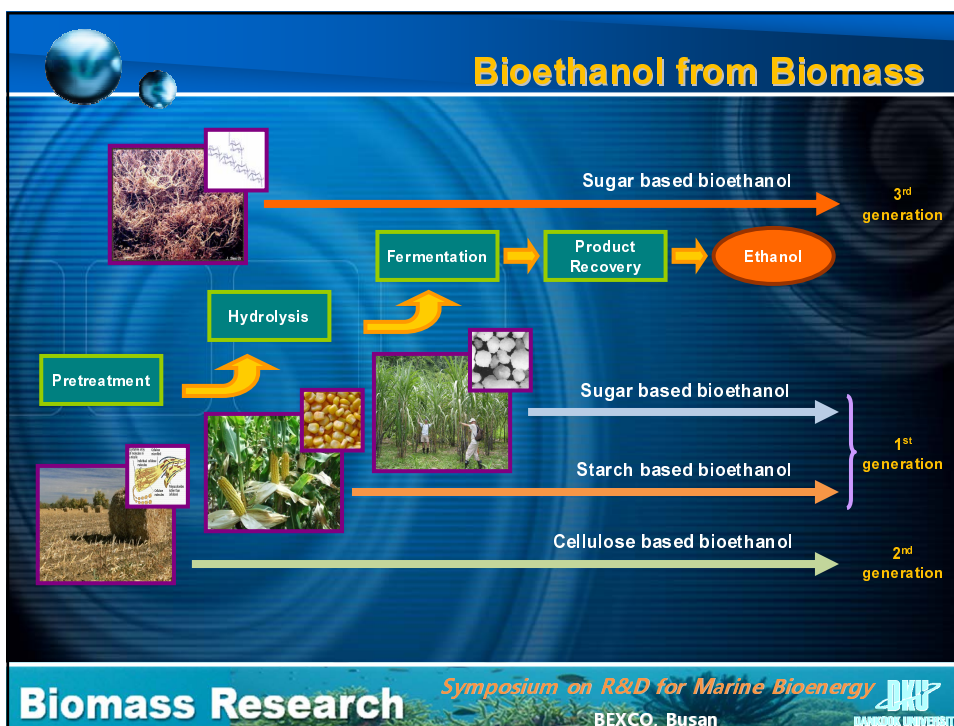
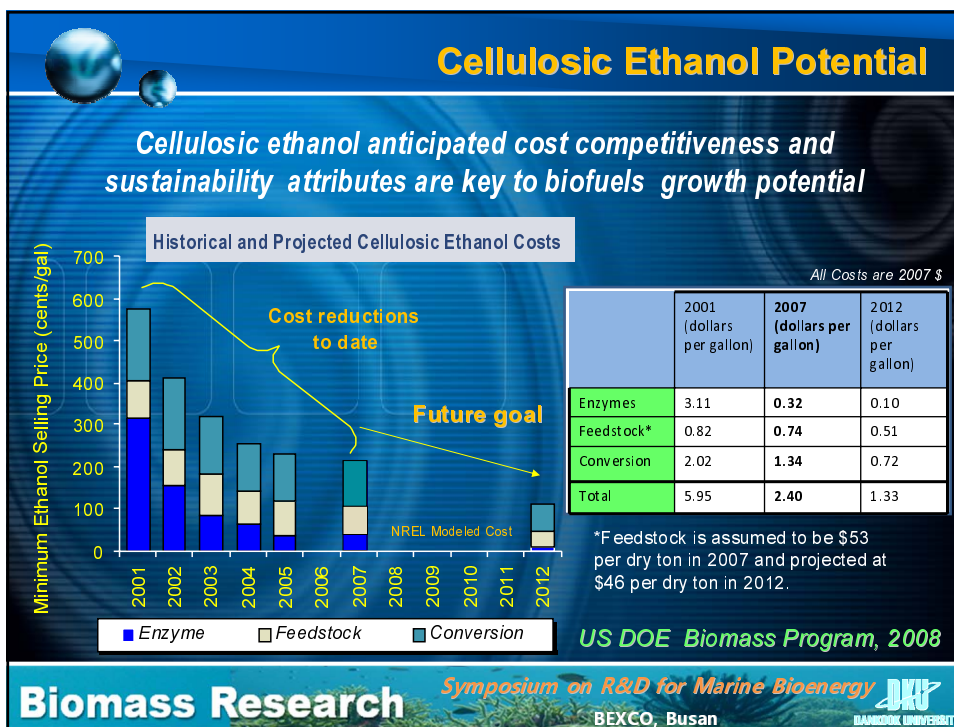
New Renewable Fuel Standard

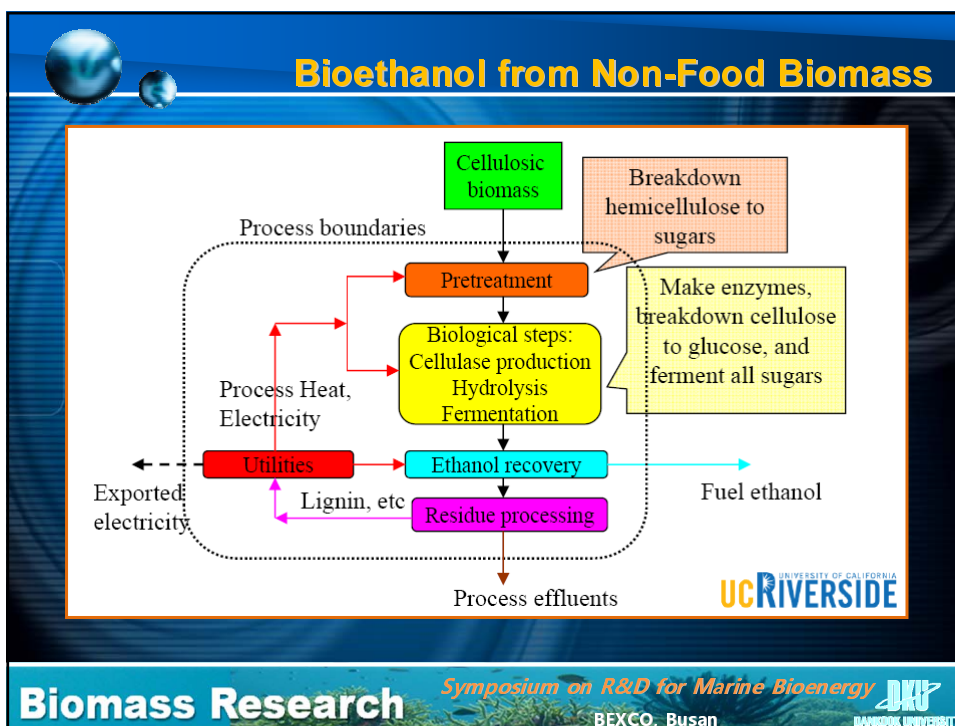
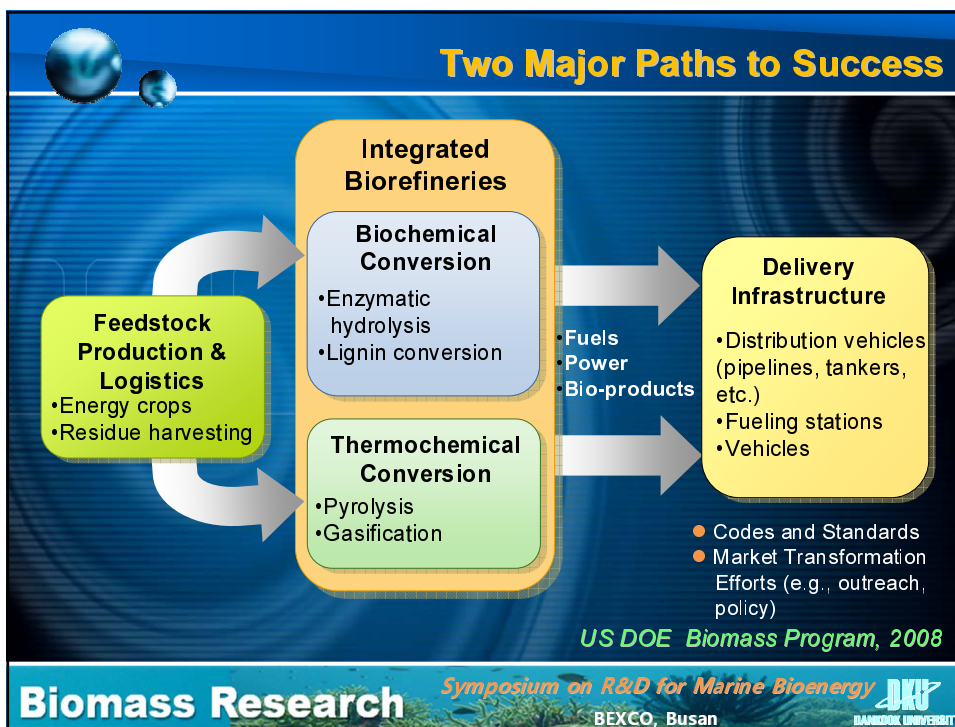
- Expand use of renewable fuels to **36 billion gallons** annually **by 2022**
- Cellulosic biofuels component
 - 3 billion gallons by **2015**
 - 16 billion gallons by **2022**
- Additional Areas of Interest and Responsibility
 - Infrastructure Development Grants
 - Numerous studies, R&D on infrastructure and other topics

Energy Independent and Security Act., 2007

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Non-Food Biomass

- **Non-Food biomass** is able to improve biofuels production capacity.
- Technologies based on non-food biomass are considered as **advanced processes** to increase the number of products and raw materials, as well as to optimize the use of biomass
- Ethanol consumption will increase. Since ethanol production capacity from cereal is limited, it is necessary to produce it **from Non-Food**.
- Conversion technologies based on the hybrid concept **cereal + non-food + ?** will be introduced.

Challenges


- **Non-food biomass is difficult to process due to:**
 - low accessibility of crystalline cellulose fibers
 - presence of lignin "seal" & hemicellulose cross-links
 - small pore sizes in lignocellulose
- **Acid pretreatment methods result in the formation of byproducts that are inhibitory to subsequent biofuels fermentation and result in a loss of sugars**

JEBI; Joint Bioenergy Institute, 2008

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Non-Food Biomass

■ **Non-Food Biomass**


Wood & wood waste from timber harvesting operations




Corn stover




Fast growing pine and hardwoods




Switchgrass



Rhodophyta




Eucalyptus




Hybrid poplar



Chlorophyta



Miscanthus



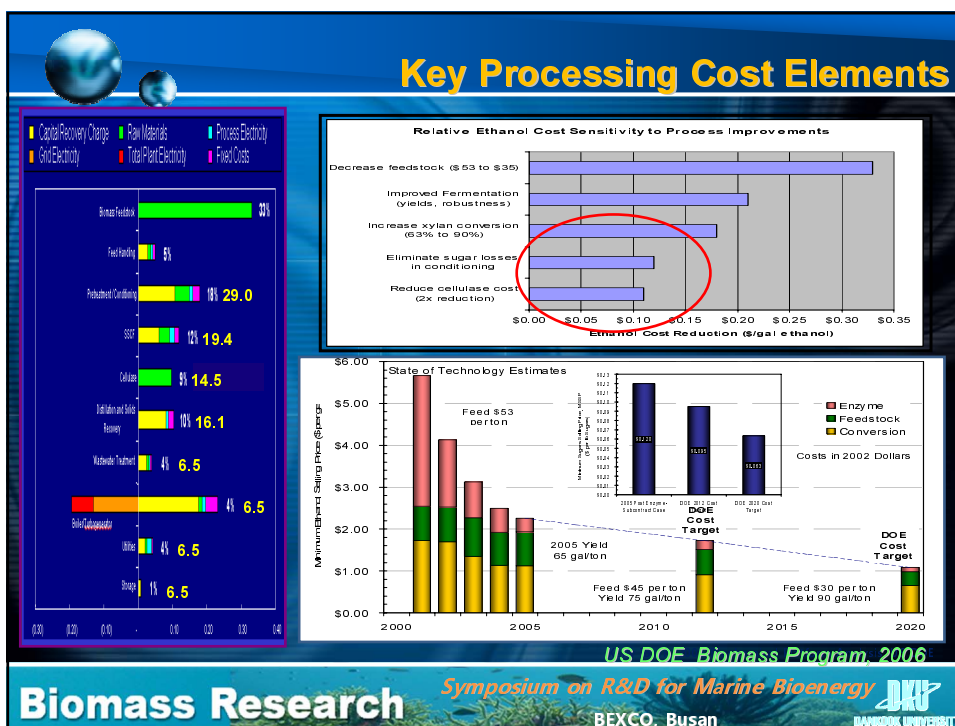
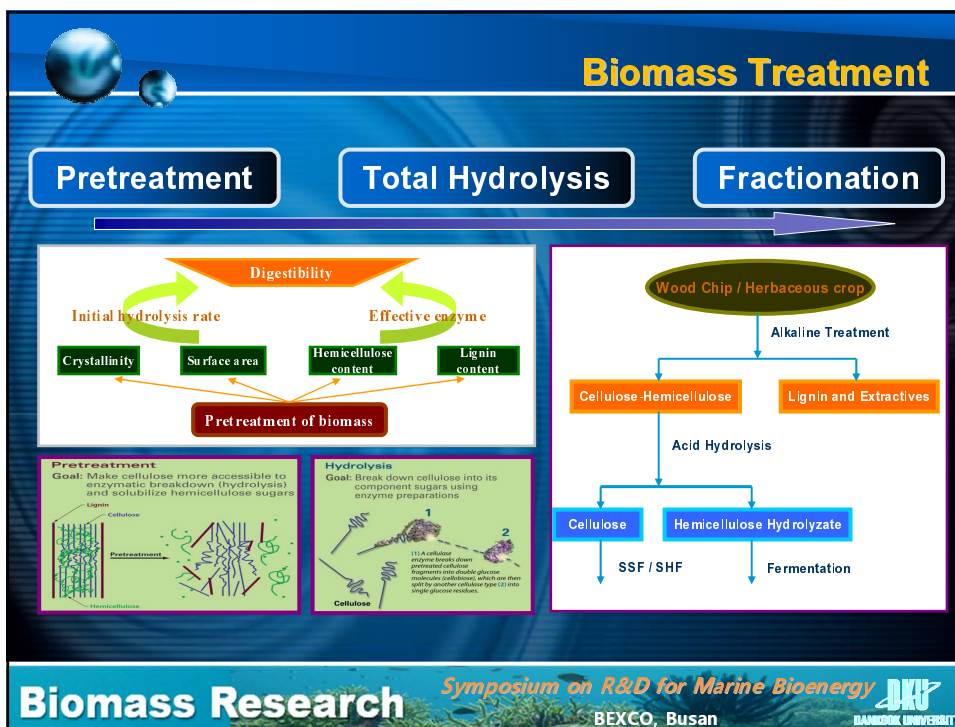
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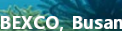

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Red Algae, Feedstocks Potential

Classification	Land Plants		Marine Plants
	Crop-Based [1 st Generation]	Wood-Based [2 nd Generation]	Red Algae [3 rd Generation]
Harvest Cycle	1-2 Times / year	1 Time / 8 years	4-6 Times / year
CO ₂ Fixation Ability (ton/ha)	5-10	4.6	36.7
Manufacturing Process	Simple	Complex (Lignin Removal)	Simple (No Lignin)
Disadvantage	Food-Related	Forest Damage	None
Cultivation Environment	Sun Light, CO ₂ , Water, Land, Fertilizer	Sun Light, CO ₂ , Water, Land, Fertilizer	Sun Light, CO ₂ , Sea Water

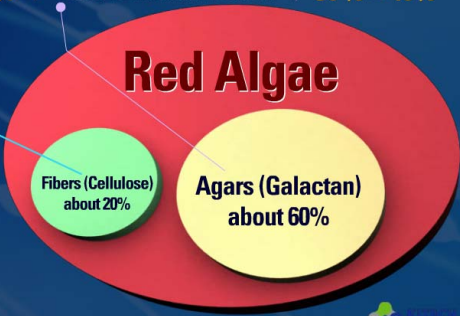
Ref.: *K. S. Kim*, KITECH, 2008

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Red Algae, Feedstocks Potential

Fermentation (>80%) → Total EtOH Yield ≈ **37%** (Wood-Based, 20-25%)




≈80% Saccharification → 16% + ≈50% Saccharification → 30% = **46%**



Red Algae

- Fibers (Cellulose) about 20%
- Agars (Galactan) about 60%

Ref.: *K. S. Kim*, KITECH, 2008

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Fractionation of galactose from *Red Algae* through dilute sulfuric acid hydrolysis

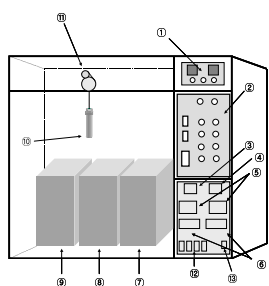
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Experimental Setup



- ① Timer and counter ② operator's control box ③ Voltmeter ④ Ammeter
⑤ Digital thermo-controller ⑥ Digital indicator ⑦ Bath (Cooler) ⑧, ⑨
Bath (Heater)
⑩ Batch reactor ⑪ Electric motor ⑫ Power switch ⑬ Main switch



Composition:

15 ml Bomb tube reactors
Pre Heater, Heater, Cooler
Automatic operating system

Purpose:

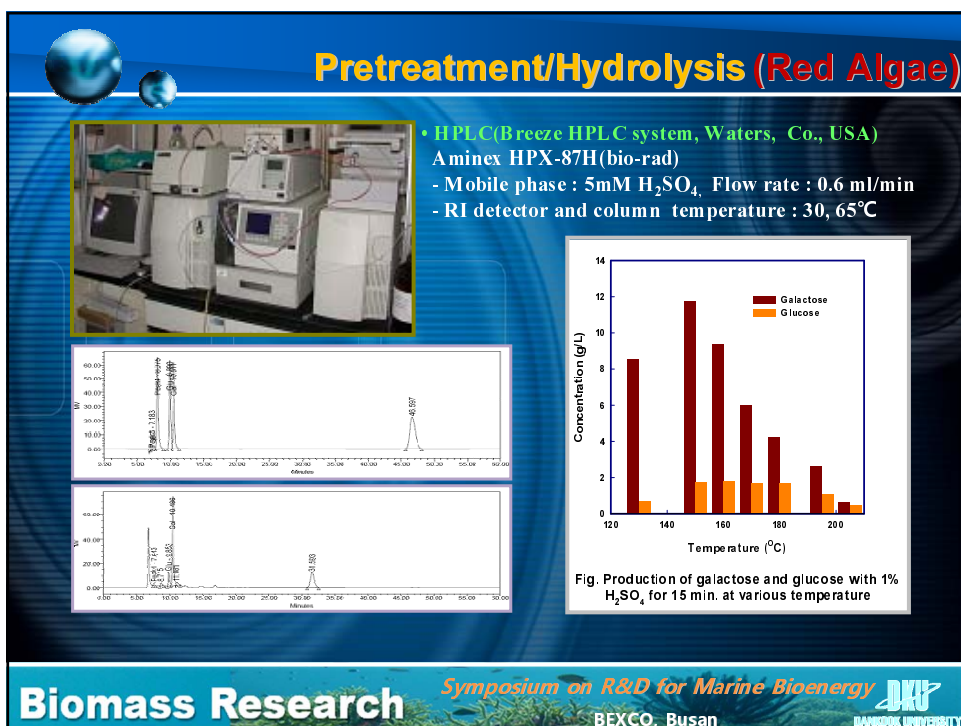
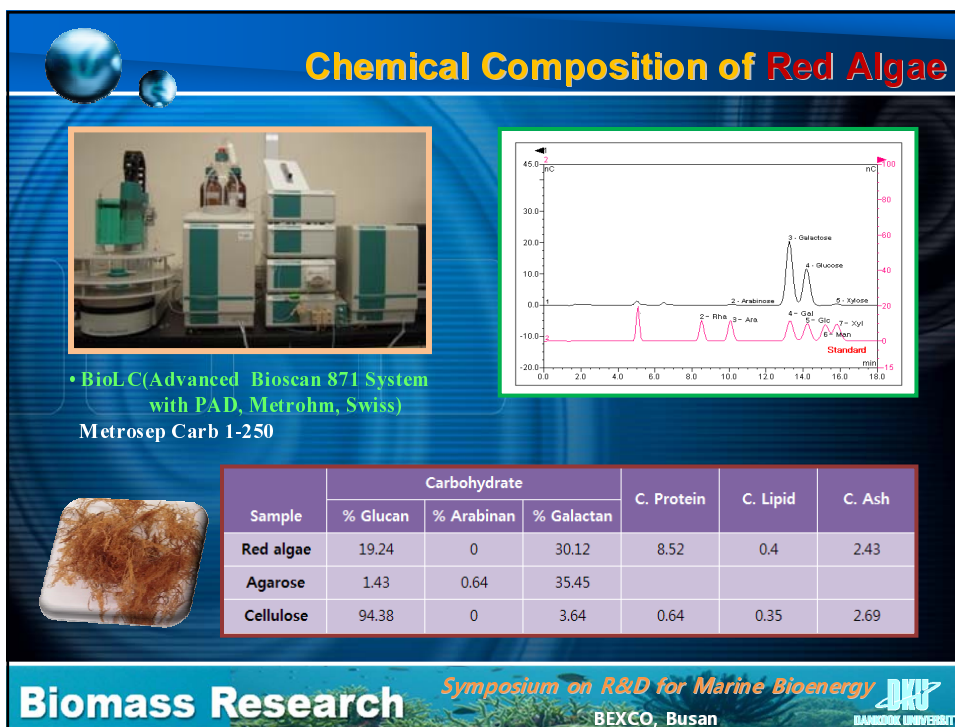
Hydrolysis of Biomass
Temperature range:
150~250°C
4 reactions can be
carried out in once

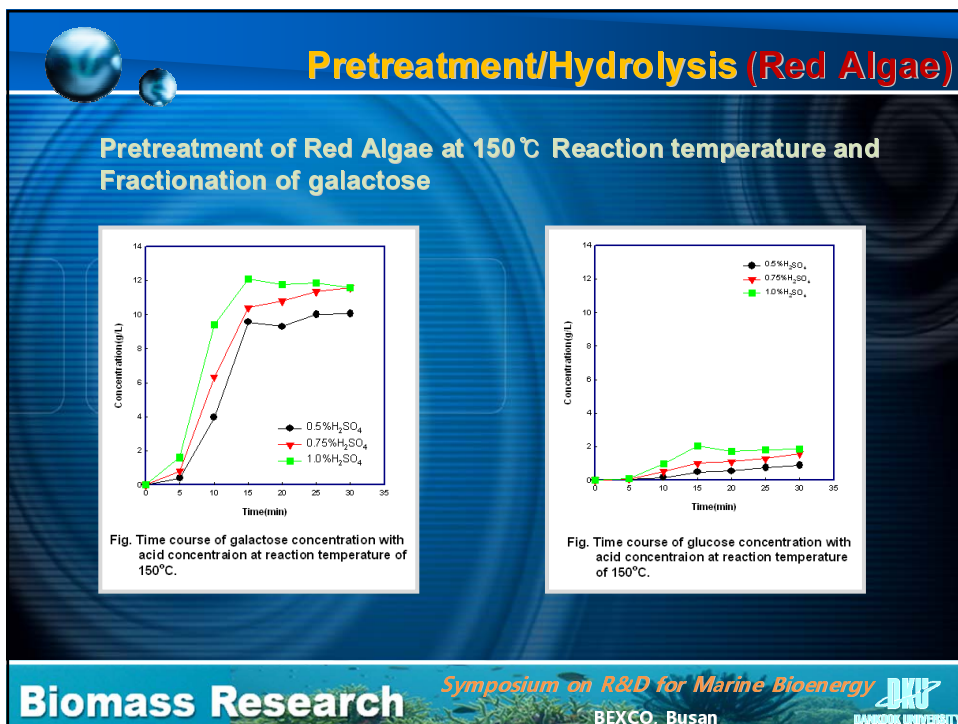
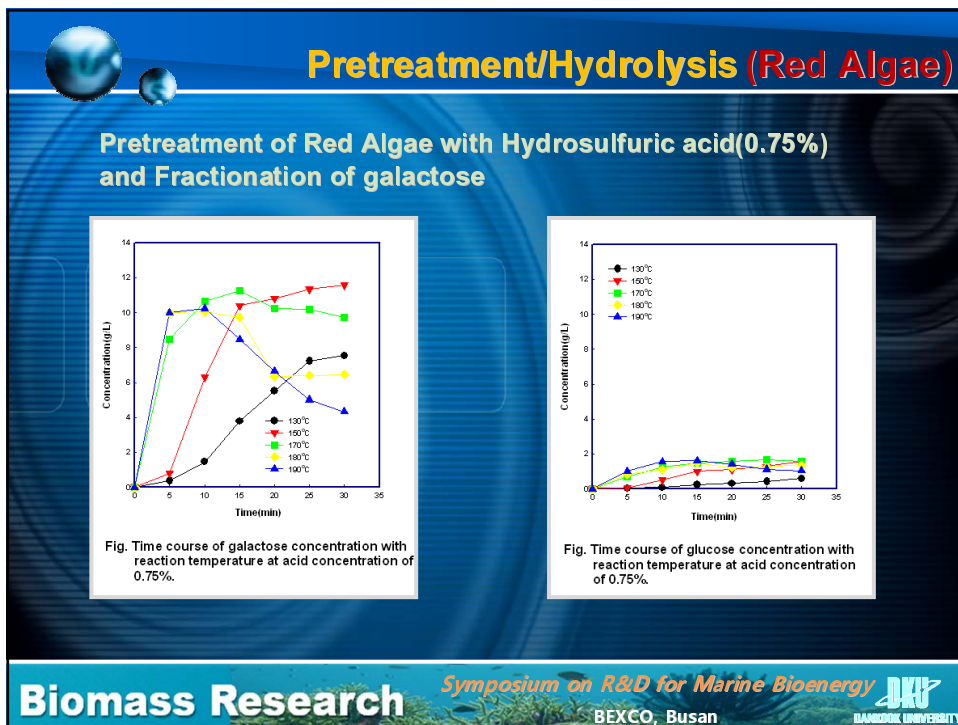
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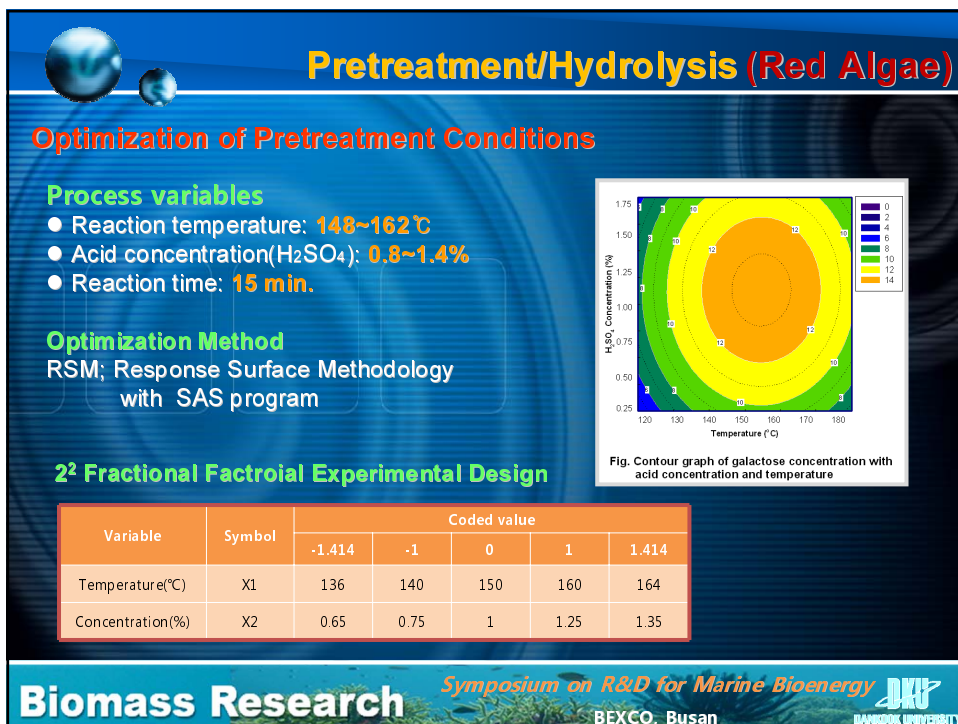
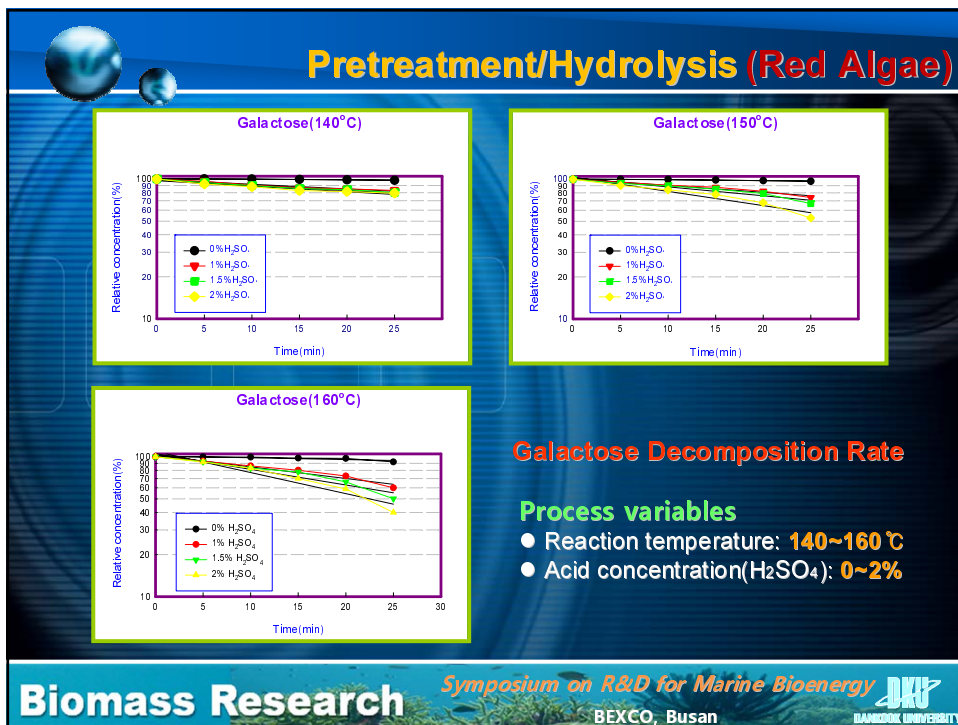
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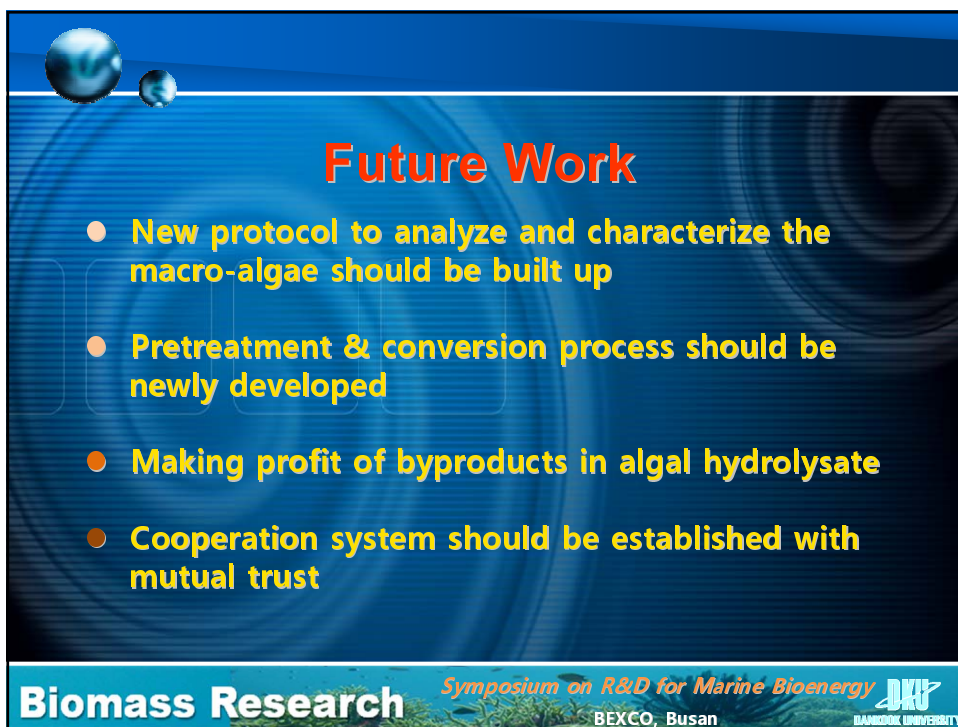
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Future Work

- New protocol to analyze and characterize the macro-algae should be built up
- Pretreatment & conversion process should be newly developed
- Making profit of byproducts in algal hydrolysate
- Cooperation system should be established with mutual trust

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*I' d like to express
my **heartfelt thanks** to you*

Kyeong Keun Oh

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