Fuel From The Sea?

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Highlands & Islands ENTERPRISE

THE CROWN ESTATE

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Seaweed

- Collected for human consumption and hydrocolloid production
- Europe- manual and mechanical harvested
- Asia – cultivated
- Traditional market likely higher price than biofuels
- Obtain biomass- cultivation near or offshore

Scoubidou System Used in France *(CEV*

Where does it come from

Seaweed Aquaculture Estimates Main Producers *(FAO 2006)*

Country	'000 tonnes Seaweed Aquaculture (Estimates 2006)
China	10,800
Philippines	1,300
Indonesia	900
Others	2,000

Seaweed Wild Harvest Estimates for Selected Countries *(FAO 2006)*

Country	'000 tonnes wet seaweed capture (Estimates 2006)
China	323
Chile	305
Norway	145
Japan	113
France	75*
Ireland	29

* CEVA estimates

Current Markets

Product	Production (t y^{-1})	Algae Harvested (t y^{-1})	Value (Mio US$)	Comments
Carrageenan	33,000	168,400	240	mainly *Eucheuma and Kappaphycus*
Alginate	30,000	126,000	213	*Laminaria, Macrocystis, Lessonia, Ascophyllum*, and others
Agar	7,630	55,650	137	Mainly *Gelidium and Gracilaria*
"Extracts"			10	
Nori	40,000	400,000 (wet, only Japan	1500	*Porphyra*

Polymers from macro-algae: stable markets (from McHugh 2003).

Seaweed as Fuel

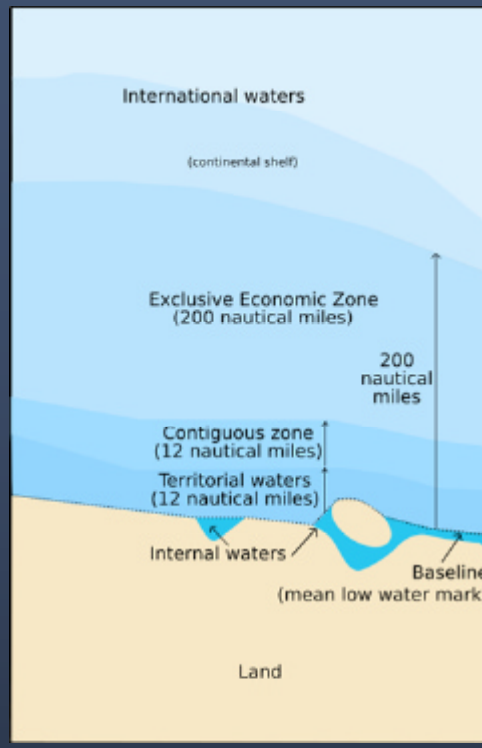
- Methane via anaerobic digestion
  - Biogas can be used to generate heat and electricity.
  - Also transport fuel (CNG)
- Fermentation
  - Highly enriched in sugars- fermented to produce bioethanol or butanol

Seaweed to methane: not a new idea, but time to revisit the technology……

- 1974, Americans looked for a renewable source of methane from the seas
- Showed that high levels of biogas could be readily produced from seaweed
- However then, off-shore seaweed farms were a failure
- Since then seaweed aquaculture has developed on a massive scale

Sangou Bay, China: the cultivation area stretches for more than 10km out to sea, its visible from space (Google Earth).

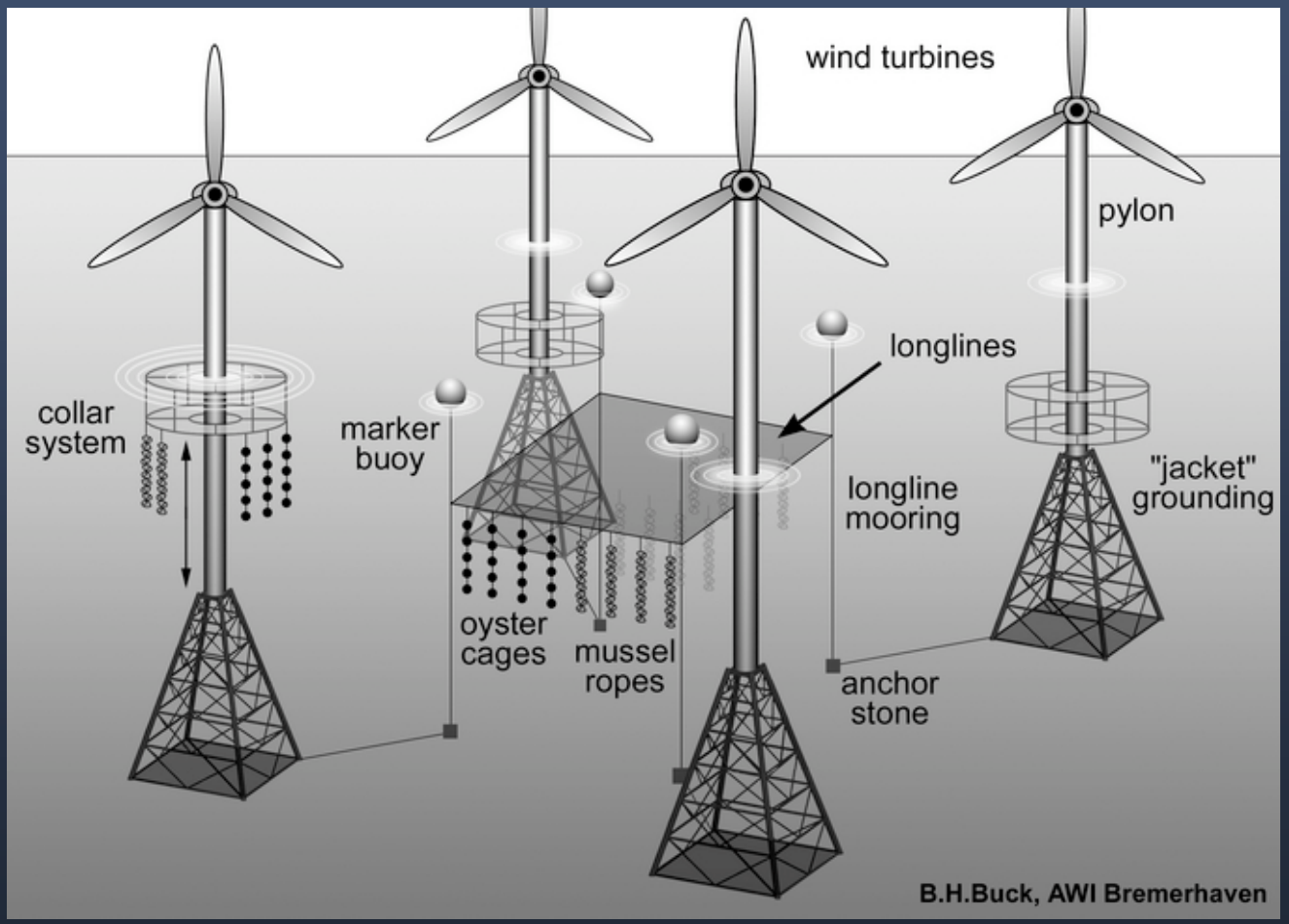
China grows 9 million tons L. japonica grown annually making it the largest single species aquaculture crop in the world



Japanese are considering seaweed for CO_2 mitigation

- **9 farms X 41.2km^2**
- **Methane from the biomass**
- **Annual energy 1.02X10^9 KWh/yr**
- **CO_2 mitigation 1.04X10^6 tonnes per annum**
- **0.9% of the 6% reduction agreed under Kyoto Protocol Framework**

Offshore Renewables



http://www.awi.de/en/research/new_technologies/marine_aquaculture_maritime_technologies_and_iczm/

Anaerobic Digestion

- Biological process- where there is little or no oxygen.
- Microorganisms degrade organic matter producing biogas- methane and carbon dioxide
- Can be harnessed and contained in a digester
- Biogas can be stored, used to run Combined heat and power (CHP) engines
- Or compressed and used as a transport fuel (just like CNG)
- Some European cities already run public transport on biogas

Methanisation of Macroalgae

- It is feasible to produce methane from seaweed using Anaerobic Digestion or AD
- Research into varying several factor that affect the process
  - e.g. separation of the juice and non-juice fractions, temperature, inoculum, nutrients, freshwater versus seawater dilution and non-dilution.
- Also advanced digester designs, process optimisation and kinetics have now been investigated.
- In general brown algae are more easily degraded than the green algae, and the green are more easily degraded than the red.

Bioethanol

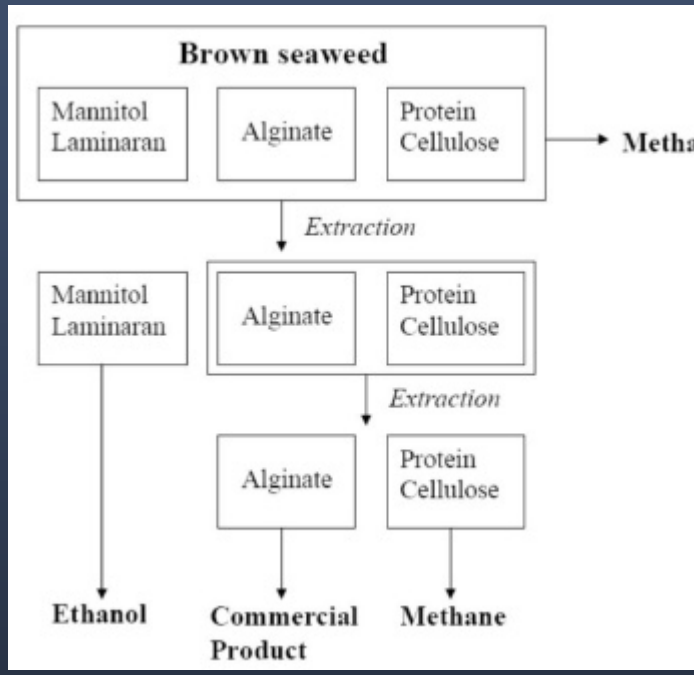
- Seaweed contains two main sugars, mannitol and laminaran
- Both are easy to extract and are by-products of the alginate industry
- Initial successful attempts convert sugars to bioethanol
- Microbes were terrestrial also occur in the marine environment
- Technological hurdles conversion of lignocellulosic (terrestrial plant) materials into bioethanol
- Doesn’t exist with seaweed biomass

In the UK and Ireland?

- Largest coast line in Europe
- To meet the complete UK transport needs how much seaweed?
- Farm 1.2 times size of UK
- Employing quarter of work force- Ok in a recession ?
- Part of solution for rural coastal communities and also potentially on a larger scale

Biorefinery solutions

- Biogas and ethanol fermentation both technically feasible from seaweed
- Commercially viable Integrated Biorefinery- extraction of energy from waste streams
- Also co-production of energy with other high valve products



A Biorefinery Concept for Brown Seaweed *(After Horn,2000)*

Large Scale Biogas & Bioethanol Production

To produce biofuel from macroalgae it will be necessary to:

- improve performance of AD and bioethanol
- screen for marine bacteria for methanisation and bioethanol production
- latest AD technology from terrestrial systems and design digestors for seaweeds
- Effects of kelp harvesting ecosystems and biofuel production on the terrestrial environment
- Key objective improvements in crop yield.
  - Selective breeding
  - Serious need to expand and enlarge existing culture banks
  - Strain selection and maintenance facilities need to be establish similar to those that exist for terrestrial plants and animals

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BioMara

Some of these questions will hopefully be answered by the Interreg IVA funded project - BioMara
Started in January '09 and includes the following partners

Partners

- **Scottish Association for Marine Science**
- **QUESTOR, a cross-border centre coordinated by The Queen's University Belfast**
- **University of Strathclyde Fraser of Allander Institute.**
- **Centre for Sustainable Technologies, University of Ulster**
- **Centre for Renewable Energy, Dundalk Institute of Technology (CREDIT)**
- **Institute of Technology, Sligo.**

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