ECONOMIC FEASIBILITY OF OFFSHORE SEAWEED PRODUCTION IN THE NORTH SEA

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Introduction
Interest in large-scale aquaculture of seaweeds in moderate temperature waters is growing. Seaweeds are a potential source of food, feed, biofuels and basis material for production of biobased chemicals. Although seaweed production is a significant market, in 2004 the world seaweed market was almost € 6 billion over 90% of which was farmed (Douglas-Westwood 2005), seaweed is not farmed at a significant scale in the North Sea.

Methodology
Research project on seaweed production in the North focus on offshore production, where possible in combination with offshore wind parks. Scientific experiments focus on development of production methods that optimize yields and can resists harsh conditions. Questions on the markets for the produce and the organisation of the (future) value-chain often remain unanswered.
In this paper we assess the economic feasibility of developing a North Sea seaweed value chain by conducting a Value Chain Analysis (Taylor, 2005). Based on scientific literature, reports, interviews and personal communications we gathered insight into the current and potential status of the North Sea seaweed value chain. We focus on the species that are endemic to the North Sea.

Findings
From publications, we gathered data on the expected costs of offshore seaweed production, focussing on seaweed production using long-lines. This literature review shows greatly differing expected costs (See Table 1).

We added findings from an on-going research project to estimate investments, labour and harvesting cost. As a results, total production costs for seaweed are estimated at between between € 1.000,-- and € 1,500,-- per tonne DM.
We then reviewed various possible usages of seaweeds to estimate revenues. The market prospects differ greatly for various usages (Table 2). Direct use for human consumption offers highest prices. In Europe this is a small market. Direct consumption by animals offers low value. It is more interesting to produce feed additives from seaweeds but more research is required on nutritional value and feed risks. The use of seaweeds for the production of biofuels seems unlikely due to the low prices that are paid for biofuel material. The most promising 'application' is biorefinery where seaweeds are refined into a range of products such alginates, chemicals and feed additives. The question then is whether or not the remaining biomass it is possible to developed a cascade of seaweed applications from high-value to low-value (e.g. combine high value chemicals with extraction of amino acids).

Conclusions and research challenges
If we relate potential revenues to expected production costs, economically viable production of seaweed seems possible. However, further prove is needed that seaweeds can be produced at these costs at a large scale. Looking at the production costs, the annual purchase of seedlings constitutes the largest cost. Technical innovation and the design of systems that enable multiple harvests per year can reduce production costs.
More data on the possibilities to establish a cascade of applications is required. For example, one can imagine the extraction of valuable hydrocolloids, followed by extraction of functional food additives and use of remaining material as source of biofuels.
Laminaria spp can be used for alginate production. At first sight, market introduction would mean competition with

cultivated Chinese seaweeds, which is not an attractive prospect. However, availability of seaweeds for alginate production is expected to suffer from supply and costs problems in the near future (Bixler and Porse 2010).

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