Low land input feedstocks: Algae technology

Jukka-Pekka Nieminen
Pauliina Uronen
15.9.2011

NESTE OIL

refining the future

Neste Oil in brief

- A refinery and marketing company concentrating on delivering fuels for cleaner traffic
- Refining of 15 million tons of oil products per year
- Listing on the NASDAQ OMX Helsinki exchange (stock symbol NES1V)
- Turnover of 11.9 billion euros in 2010
- Operations in 15 countries
- Personnel 5,000
- State of Finland as primary owner (50.1% holding)

Production capacity is increasing

- In 2012, Neste Oil's production capacity of NExBTL renewable diesel totals 2 million metric tons

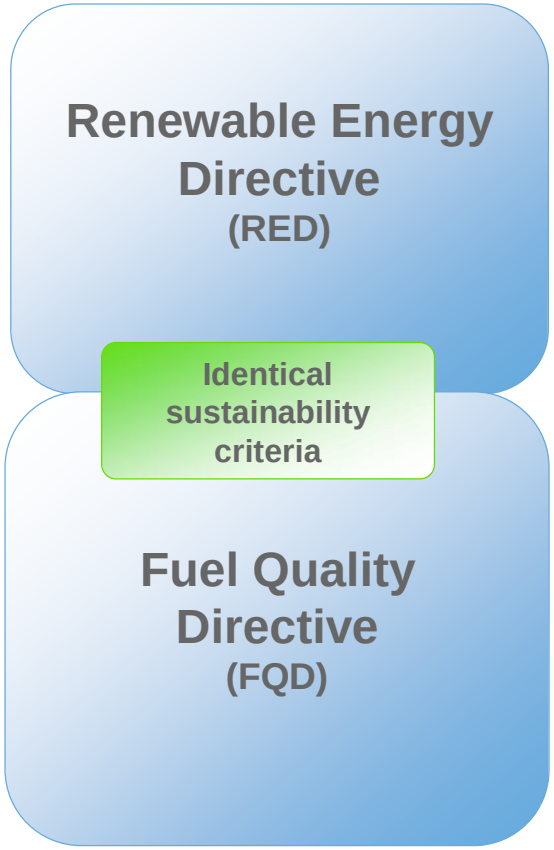
Location	Capacity	Status
Porvoo 1	190 000 t/a	Started up in 2007
Porvoo 2	190 000 t/a	Started up in 2009
Singapore	800 000 t/a	Started up in 2010
Rotterdam	800 000 t/a	Start up

Change in the energy industry

- Population growth, especially in the developing countries.
- Fossil crude oil reserves are being depleted.
  - The output at existing fields is estimated to drop by almost two-thirds by 2030.
- Traffic volumes and emissions are increasing, especially in the developing countries.
  - Traffic volumes are expected to triple by 2050.
  - By 2030, the global CO_2 emissions will be more than 50% higher than today (Source: IEA).
- Energy consumption is growing strongly, driven by China and India.
- Security of energy supply has become a key economic and political issue.
- Concern about climate change and the state of nature.

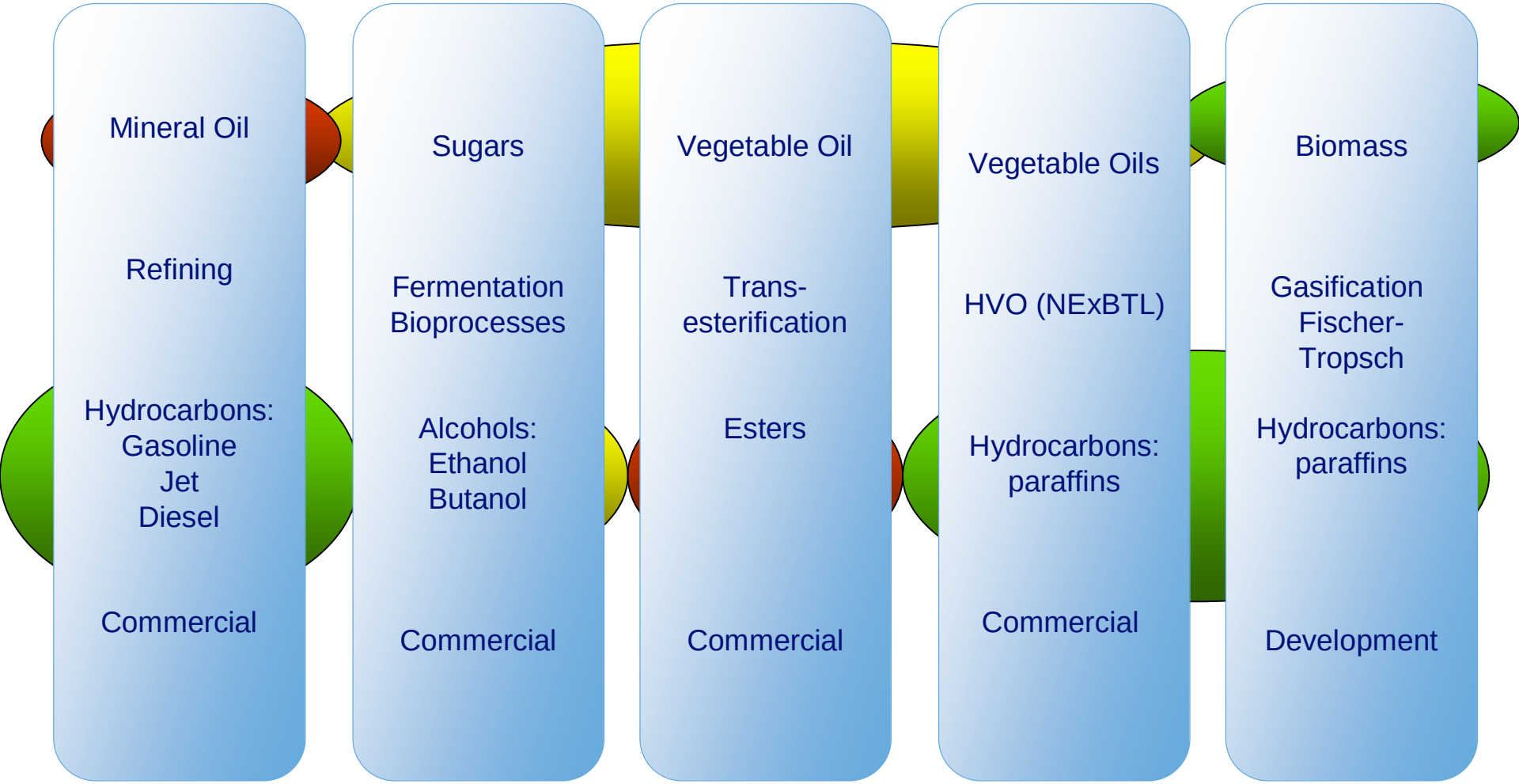



Biofuel legislation in Europe



- Renewable Energy Directive that came into force in 2010 requires member states to increase the energy content of transport fuels from renewable raw materials to 10% by 2020.
- The use of biofuels should result in a clear reduction of GHG emissions (compared to fossil fuel)
  - 35 % savings from 2011 on
  - 50 % savings from 2017 until 2020
  - 60 % savings from 2018 on within those installations that started production after Jan 1st, 2017)
- Technical specifications for fuel properties and binding targets to reduce fuels' greenhouse gas emissions
  - The GHG emissions of gasoline, diesel and other fuels should be reduced by 6% by 2020

Alternative Fuel Options



Neste Oil sees algae oil as a potential feedstock because:

- Free energy from the **sun** = primary producers
- Algae have a high oil production potential
  - realistic aim is **20-30 t/ha/year**
- Algal oil is a **suitable** feedstock for NExBTL renewable diesel
  - Fatty acid profile similar to vegetable oils
- Use of CO2 emissions
- Use of **seawater** or waste water
  - fresh water need low
- Cultivations can be located on unfertile land
- Scale-up easy (replicate modules)

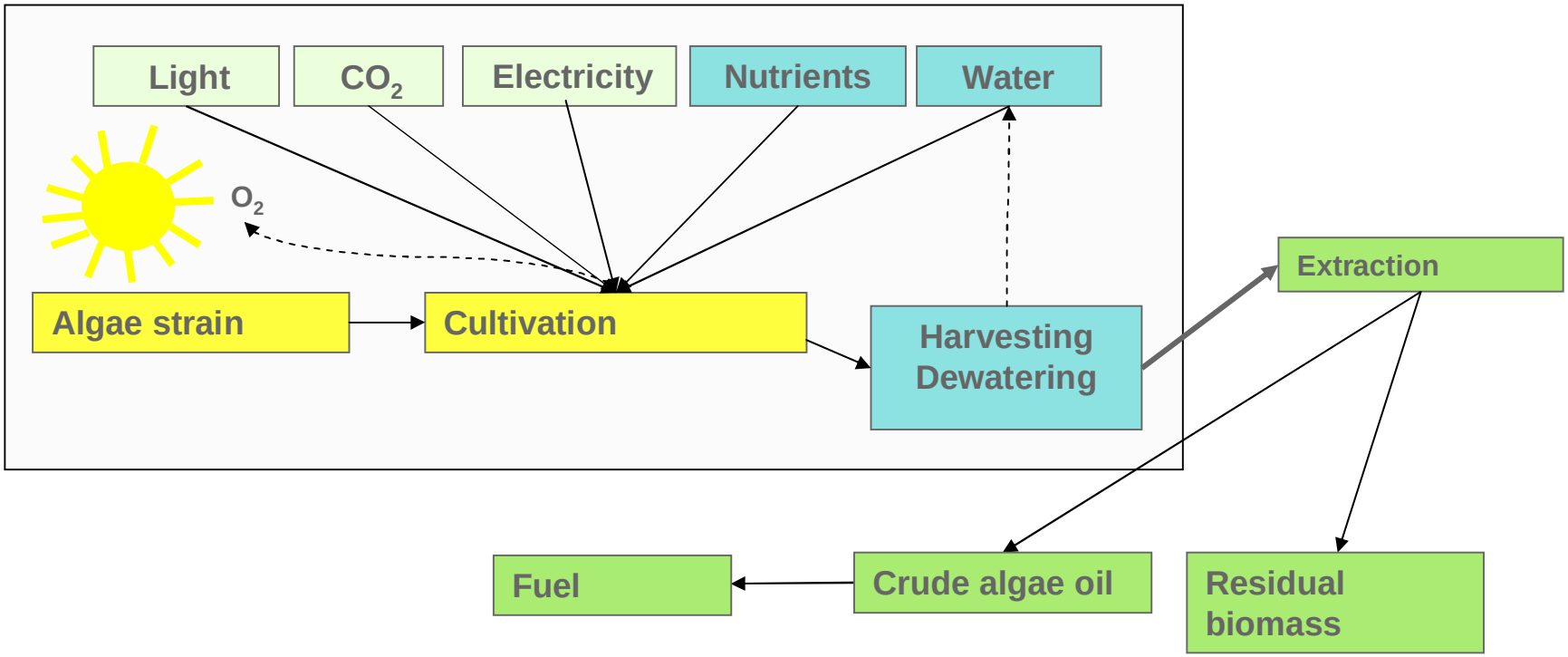
Crop	**Oil yield Gallons /acre**	**Oil yield Tonnes /ha**
Corn	18	0,2
Soybean	48	0,5
Rapeseed /canola	127	1,2
Jatropha	202	1,9
Oil palm	635	5,9
Algae (low productivity)	1200	11
Algae (very high productivity)	10000	90

Algae – an option for the future

- There is **no commercial production of algae oil** for biofuel purposes yet
- Commercial production of algae biomass is focused on high-value products (food additives, cosmetics, aquaculture)
  - low value oil demand and markets opened during few recent years
- **Production costs are strongly based on Capex**

-> Capex costs can be reduced by improvements in photosynthetic efficiency and lipid yield together with cultivation system development = **both biology and technology in focus**

Algae cultivation and processing steps



The whole value chain must be evaluated

- Wild strain potential still mainly unexplored
  - only a small fraction of over 30 000 algae species evaluated for fuel production purposes
- Optimising algae strains and growth conditions for oil production: growth and lipid production

  -> These improvements affect strongly Capex
- Development of cost-efficient technologies is in early development stages, especially cell harvesting and oil recovery technologies
- Patents in technology and algae strain development are increasingly being filed
- Biorefinery concepts are a necessity in order to maximise the use of residual biomass and thus value chain.
- Strong need for collaboration and update of regulation and processing methods to ensure usability of residual biomass
- Valorisation of the residual biomass is crucial to enable cost-efficiency

Scale-up

- Need for investments for test production sites and scaling-up
- A relatively small area (1-2 ha) is enough to prove the concept

  -> Modular scale-up possible
- Initiatives for algae pilot plants are increasing globally. Collaboration needed between commercial players in the field: cultivation, processing, fuel refining, valuable oil processing, protein processing, use of other valuable compounds

Example
AlgaePARC - promoting scale-up

- Aim: sustainable production of microalgae as feedstock for fuel, chemicals, food and feed at industrial scale
- Operation and scale-up of photobioreactors, i.e. light regime, mass transfer and photosynthetic efficiency
- Smaller reactor size 2,4 m^2
- Large reactor size 24 m^2




Regulation

- Development of GM organisms and other sustainability areas should be assessed
  - algae are not yet included in the EU RED directive
  - public acceptance
- Sustainability: environmental, social and economic impacts
- LCA
  - Cultivation systems (photobioreactors) and materials
  - Source of nutrients – recycling or use as feed, use of fertilizers
  - Use of CO_2 source (fossil/non-fossil)
  - Energy source and energy consumption
  - Water type (saline, fresh, waste) and amount

Review of the EBTP Strategic Research Agenda Update 2010

R&D needed for:

- Complete chain/biorefining approach
- Strain selection and optimisation – yield rates, contaminants
- Applied R&D for production scale
- Scale-up studies – industrial scale techniques
- LCA and energy balance
- Advances vs. disadvantages of open pond systems versus closed loop bioreactors
- GMO benefits and risks
- Use of wastes and residues


refining the future
NESTE OIL
NESTE OIL
refining the future