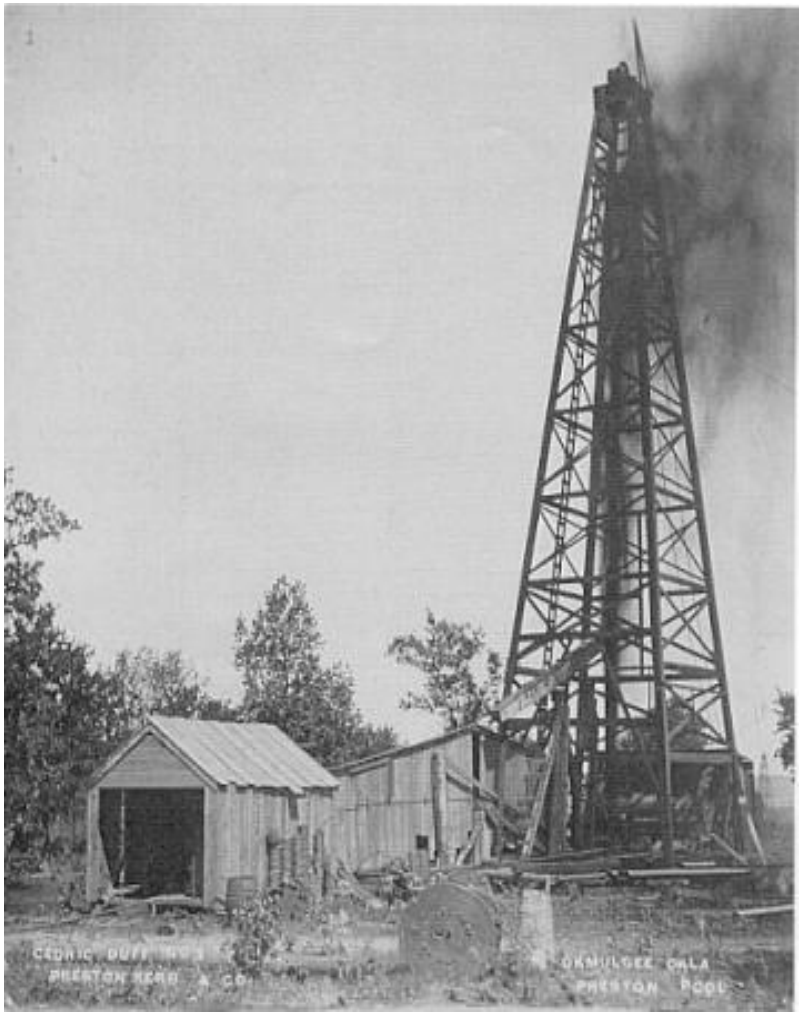
AER Limited

www.aer.ie

September 16th 2008

Confidential


CEDRIC DUFF
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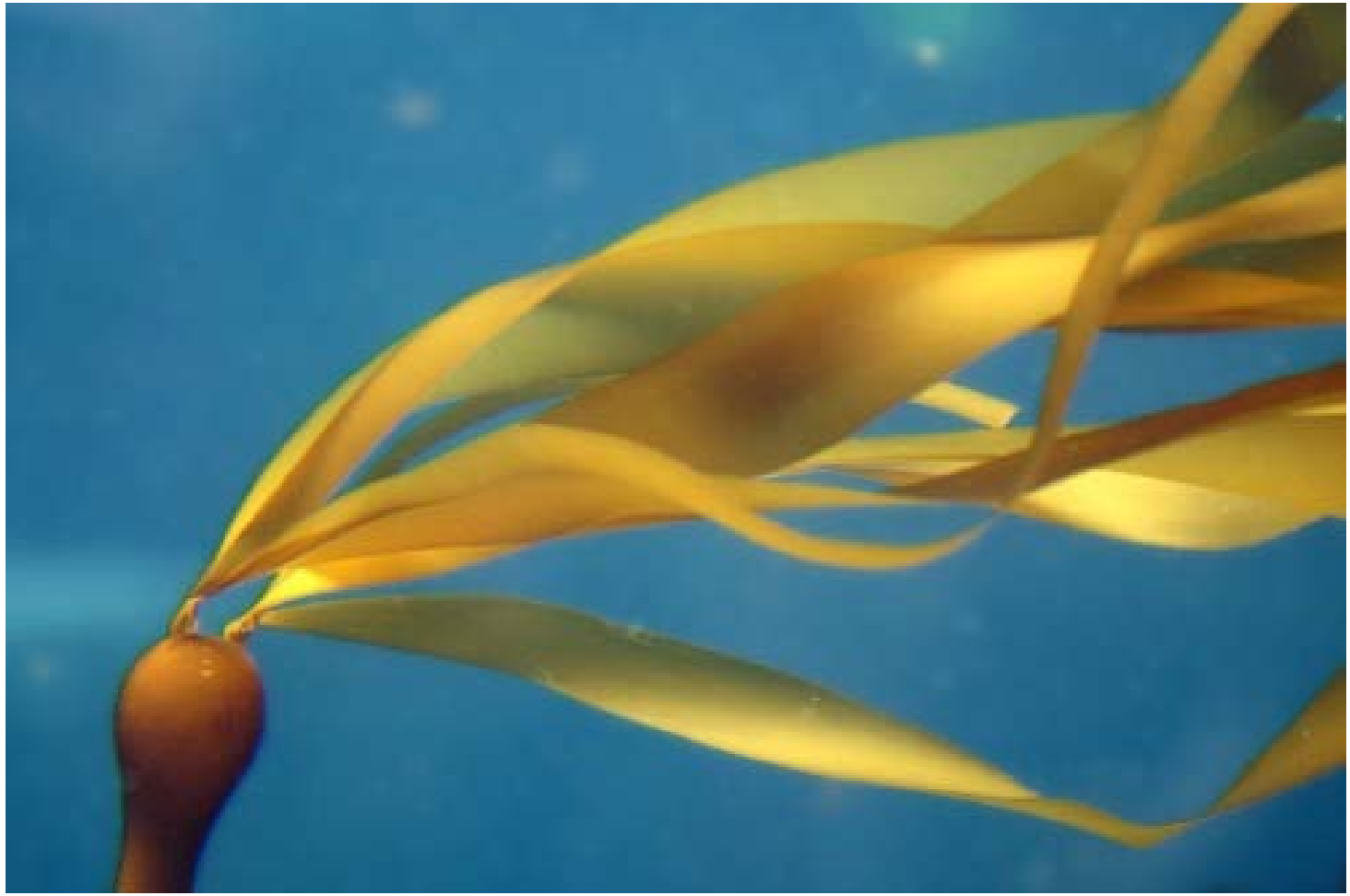


AER highlights

- Established in 2006 by team with strong biofuels and energy experience
- Team has operated independent ethanol distillery at Cooley for over 40 years
- Won government tender to supply ethanol to the Irish market for the period 2007-2011
- Leading world class research and development on next generation biofuels
- Assessing bioenergy projects in Africa, Eastern Europe and the Caribbean
- Evaluated potential for ethanol production at former sugar plant in Mallow

AER is a leading Irish based bioenergy company

AER horizons of growth

Launch
2006

- Be a leading supplier of ethanol to the Irish market

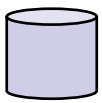
Grow
2007 - 2009

- Supply ethanol to the world market from low cost, large scale production facilities
  - Establish production facilities in Europe, the Caribbean region and Africa

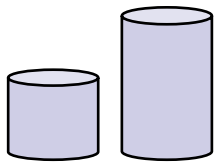
Expand
2007/8 - 2012

- Research and test next generation biofuel feedstock (e.g., enzymatic conversion of cellulose/ algae to ethanol; bio-refining)
- Partner with companies and universities on biofuel research and development and other alternative energy solutions

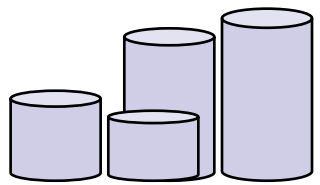
Volumes of biofuel



15-20 million litres per year

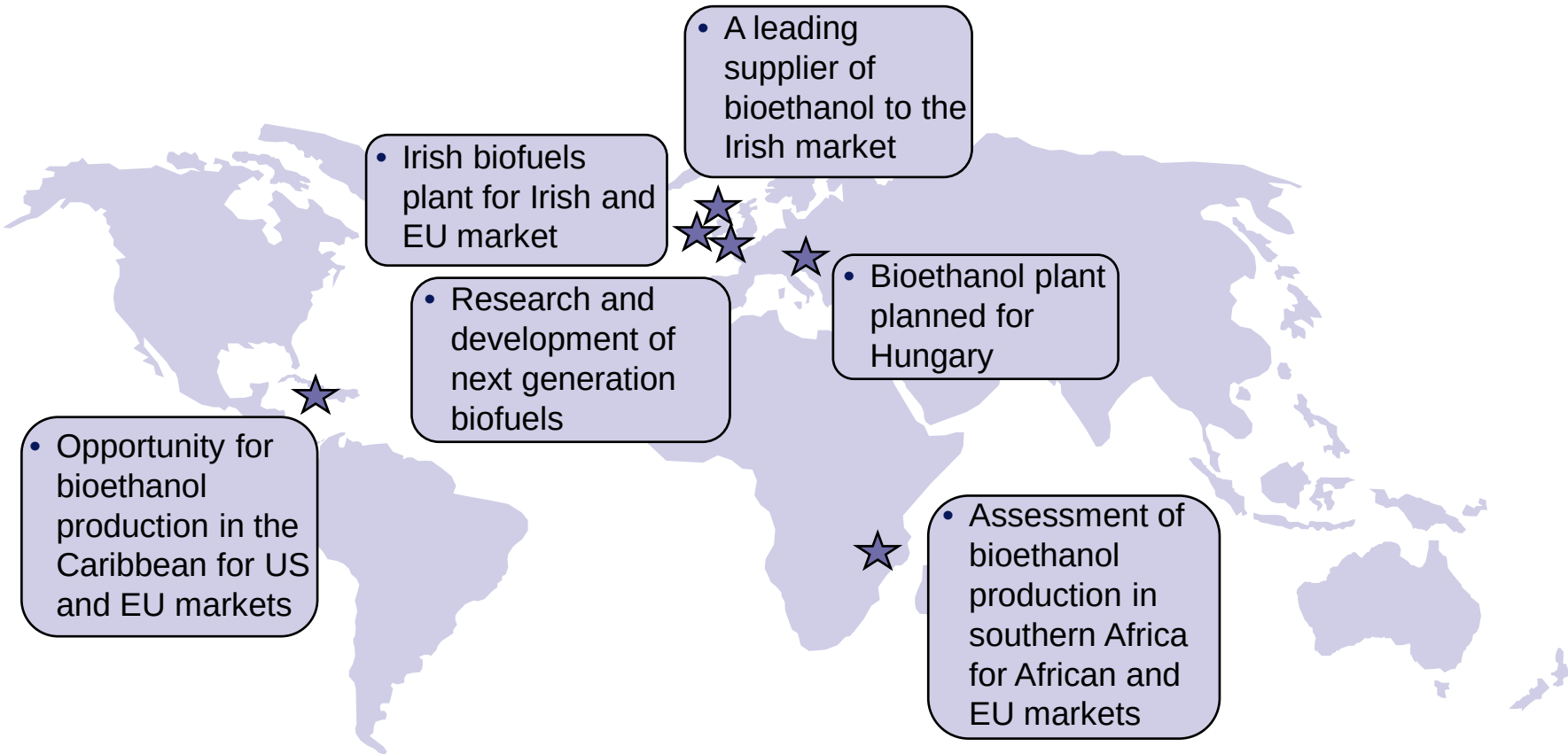


100-150+ million litres per year



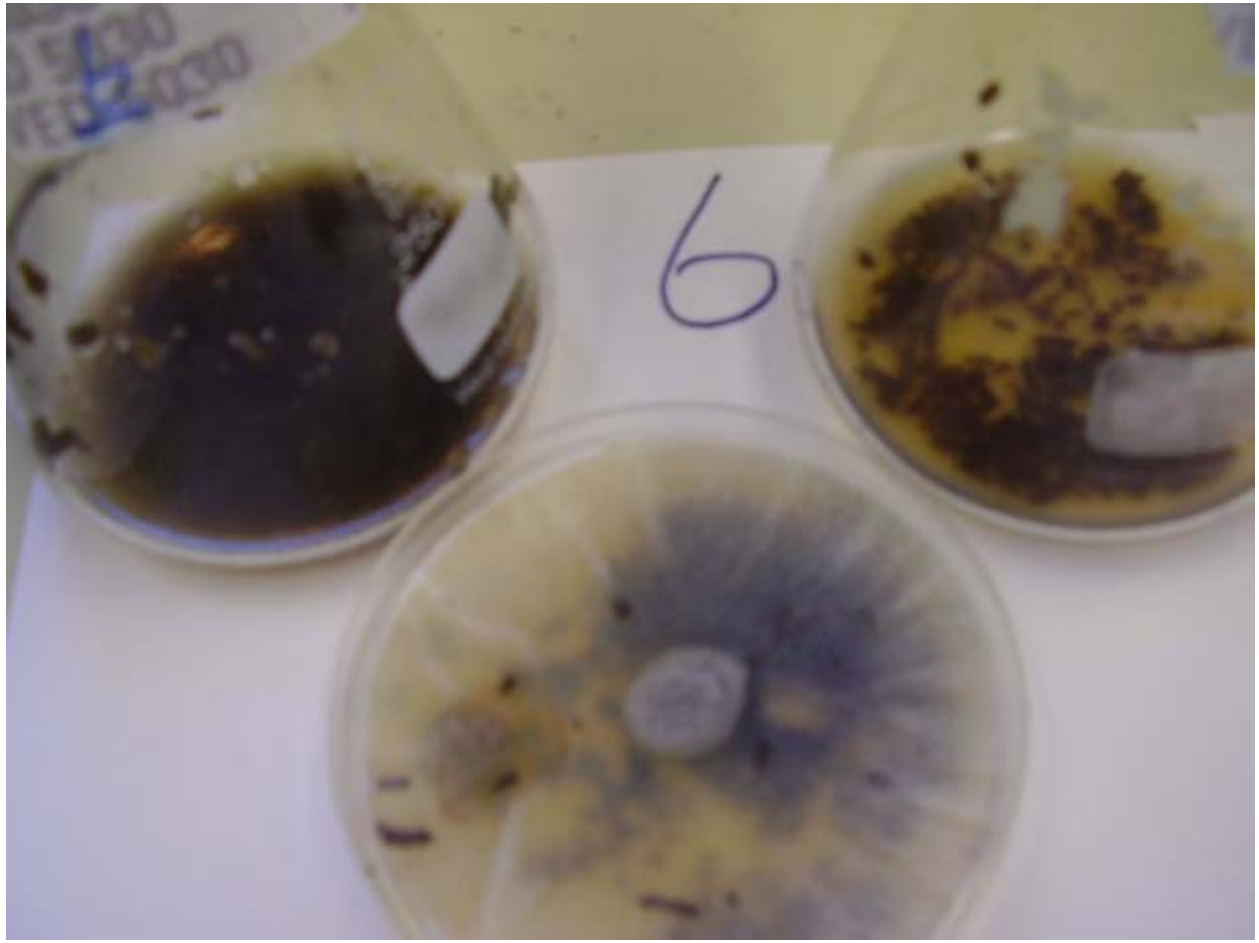
150-300 million litres per year + alternatives

AER is involved in several international biofuels opportunities



Source: AER

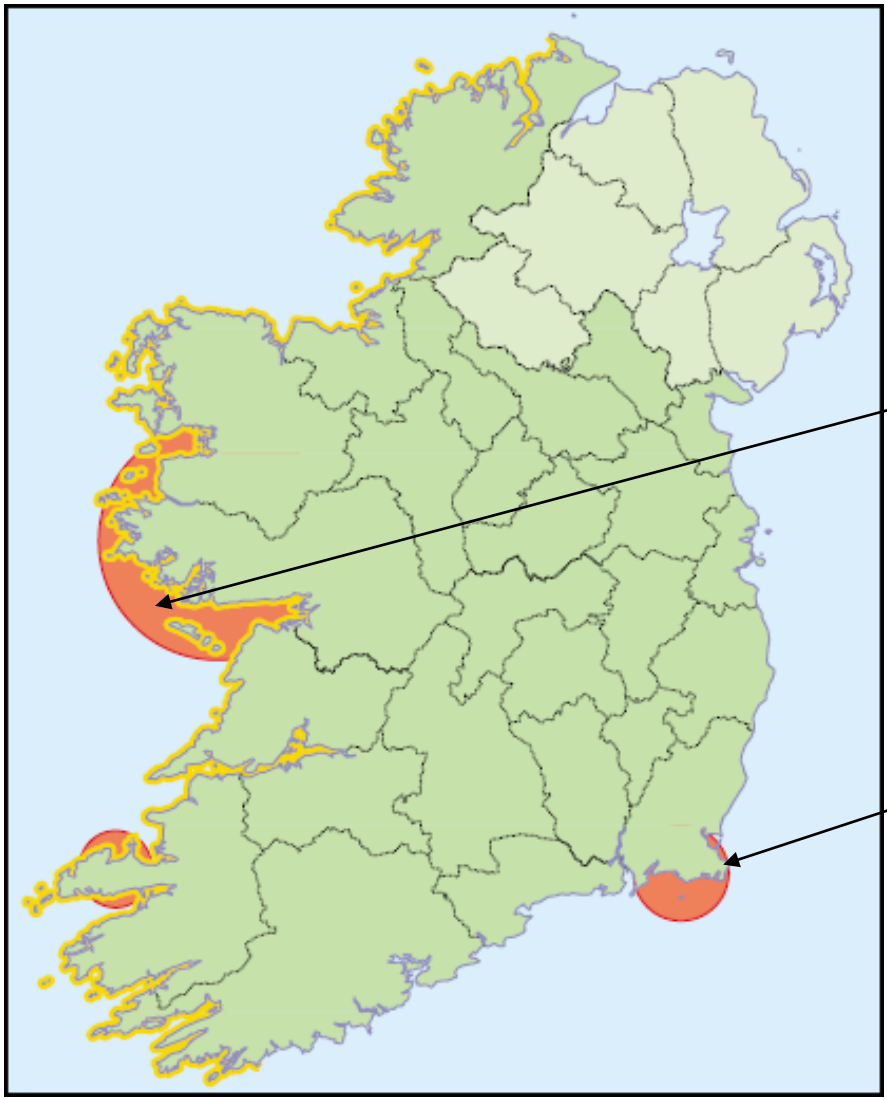
Proven conversion of algae to biofuel in our lab work



One of 34 samples of algae tested

Source: AER

Examples of typical macroalgae available in Ireland



Location of naturally occurring macro-algae in Ireland

Laminaria (600,000 tonnes available)

Ascophyllum (75,000 tonnes available)

Source: AER, BIM, ISIO, Marine Institute, NUIG

Macroalgae tested for conversion to biofuel

Brown Algae
Laminaria digitata
Laminaria hyperborea
Laminaria saccharina
Sacchoriza polyschides
Alaria esculenta
Fucus serratus
Ascophyllum nodosum
Hymanthalia elongata
Dictyota dichitoma

Green Algae
Ulva Lactuca
Enteropmorpha intestinalis

Red Algae
Palmaria palmata
Chondrus crispus
Porphyra umbilicalis
Calliblepharis iubata/ciliata
Asparagopsis armata
Phycocodrus rubens
Delleseria sanguinea
Plocamium cartilagineum
Polysiphonia lanosa

Analysis:
- 34 algae samples harvested in April and October
- Incubated at 70 deg C for 48 hours
- Contents analysed by high performance anion exchange chromatography

Results:
- Successful conversion of complex algal structures to oils and simple sugars

Source: AER

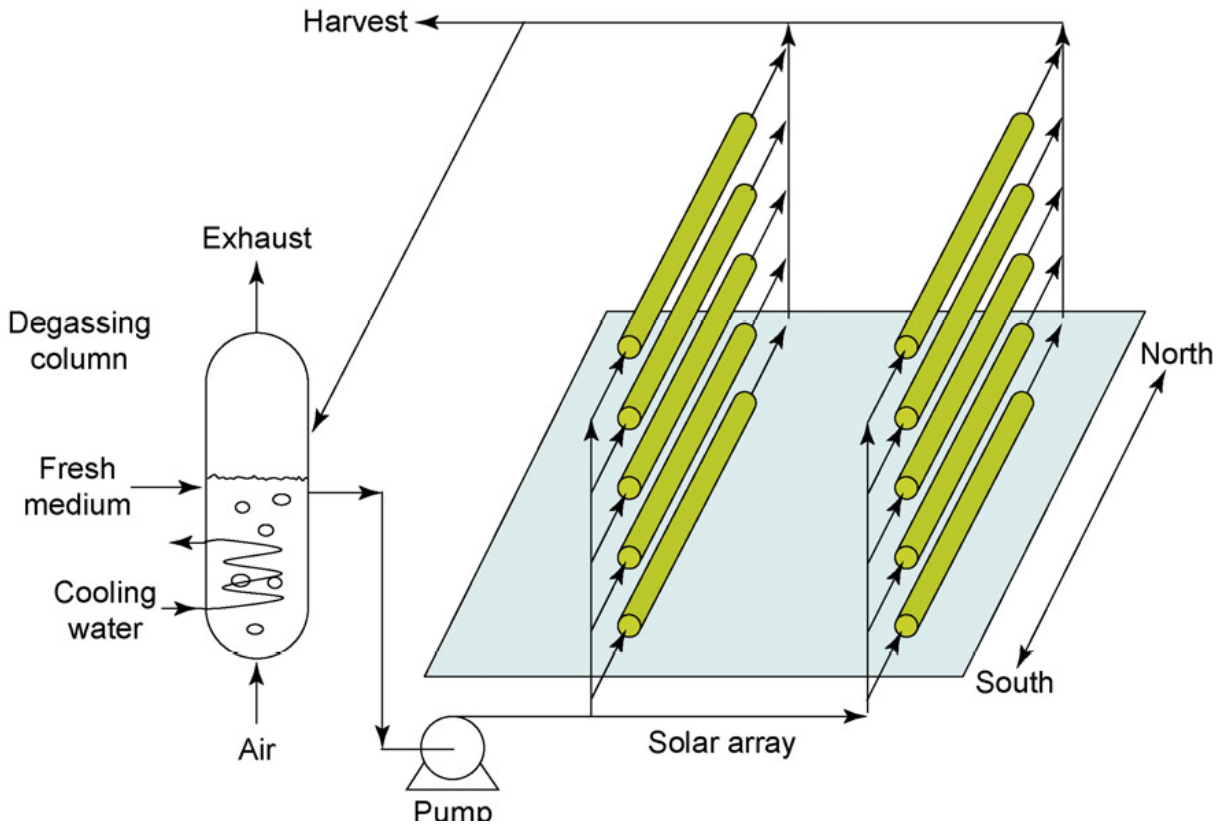
Microalgae tested for conversion to biofuel

Microalgae species	Description
Giraudiopsis stellifer (heterokonta; Ochrophyta)	A small brown-gold alga Giraudyopsis stellifera has been recorded from the Atlantic coast of France, Punt a Deseado in Patagonia, Argentina and the Isle of Man. Reportedly contains big granules of intracellular carbohydrate
Nematochrysopsis/Sacinochrysis (heterokonta; Pelagophyceae)	Heterokont alga found off the Atlantic coast of France, in the western Mediterranean Sea and in the northern Adriatic Sea. Reportedly contains big granules of intracellular carbohydrate
Aureocalvia	Reportedly again contains granules of intrcellular carbohydrate
Nannochloropsis (Eustigmatophytes)	Nannochloropsis is a small green algae that is extensively used in the aquaculture industry for growing. They are unicellular with polysaccharide cell walls and are found in marine environments
Skeletonema (Diatom)	Does not produce exo-polysaccharide but has a large amount of chrysolaminarin
Porphytidium/Rhodella	They are red unicellular algae containing rhodamylon (starch/ glucose based polysaccharides) as well as sulfated galactans (galactose based polysaccharides)
Pavlova (haptophytes)	The chloroplasts are pigmented similarly to those of the heterokonts, such as golden algae, but the structure of the rest of the cell is different and contain large ammounts of intracellular paramylon starch
Phaeocystis pouchetti/ Phaeocystis globosa	Found throughout the North Atlantic, often on shorelines in prolific foam formations. Can contain high carbohydrate content of over 60%
Isochrysis galbana/ Tetraselmis/ Chaetoceros muelleri (Diatom)	Widely cultured for use in aquaculture industry such as shellfish hatcheries

Source: AER

Bioreactor to be operated at a power generation facility

Schematic



A tubular photobioreactor with solar collectors located at a power station will use heat and CO_2 emissions to aid the growth of algae

Source: National University of Ireland, Galway

Suggested focus of research themes of the Biorefinery and Bioenergy Competence Centre

- Research theme 1: Next generation feedstock analysis
  – Optimal culturing and use of grass (major) and algae (minor)

- Research theme 2: Conversion technology
  – Conversion of feedstock to fuels and biorefinery co-products

- Selected complementary research themes
  – e.g., municipal solid waste; wood; additional conversion technologies and biorefining

Additional information

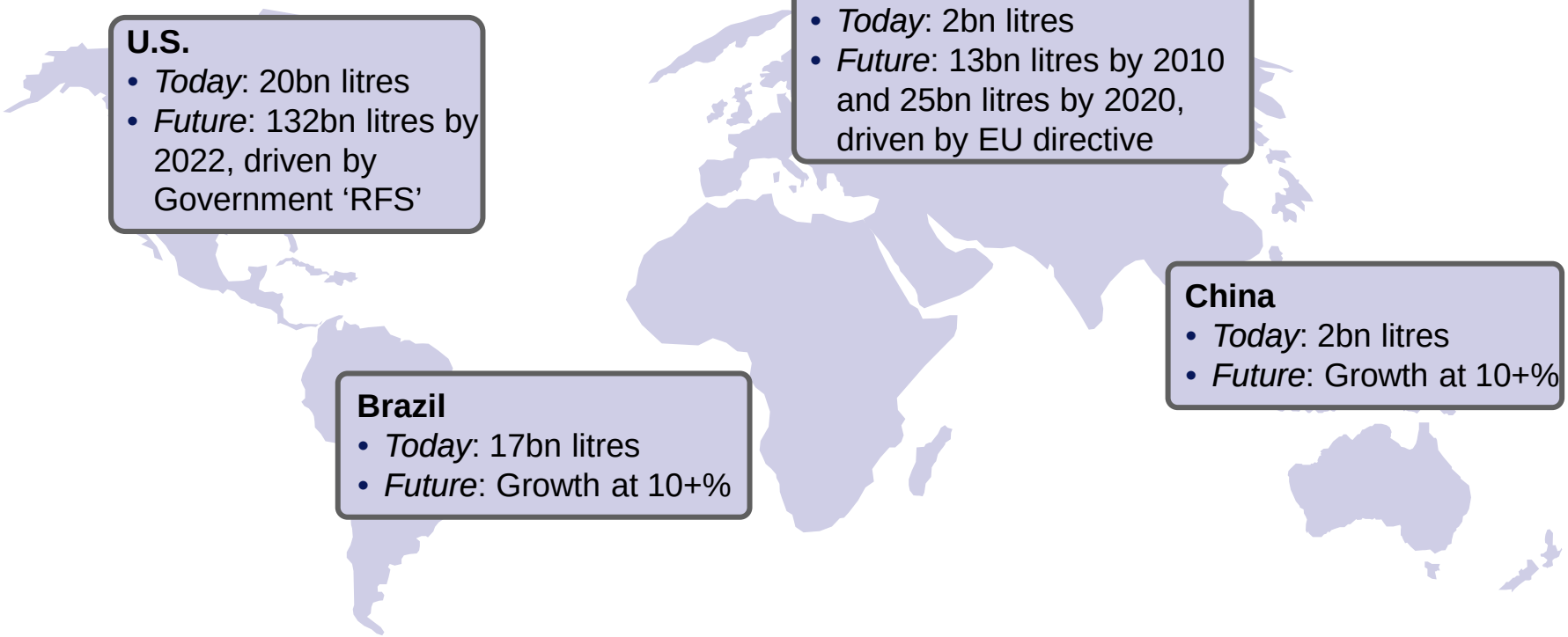
Scale up of enzyme production for algae-to-biofuel to 100 litres

Dr Patrick Murray at our 100 litre ‘fermenter’ test facility

Source: AER

Global biofuel demand is growing rapidly

Ethanol consumption



U.S.
- *Today*: 20bn litres
- *Future*: 132bn litres by 2022, driven by Government 'RFS'

Europe
- *Today*: 2bn litres
- *Future*: 13bn litres by 2010 and 25bn litres by 2020, driven by EU directive

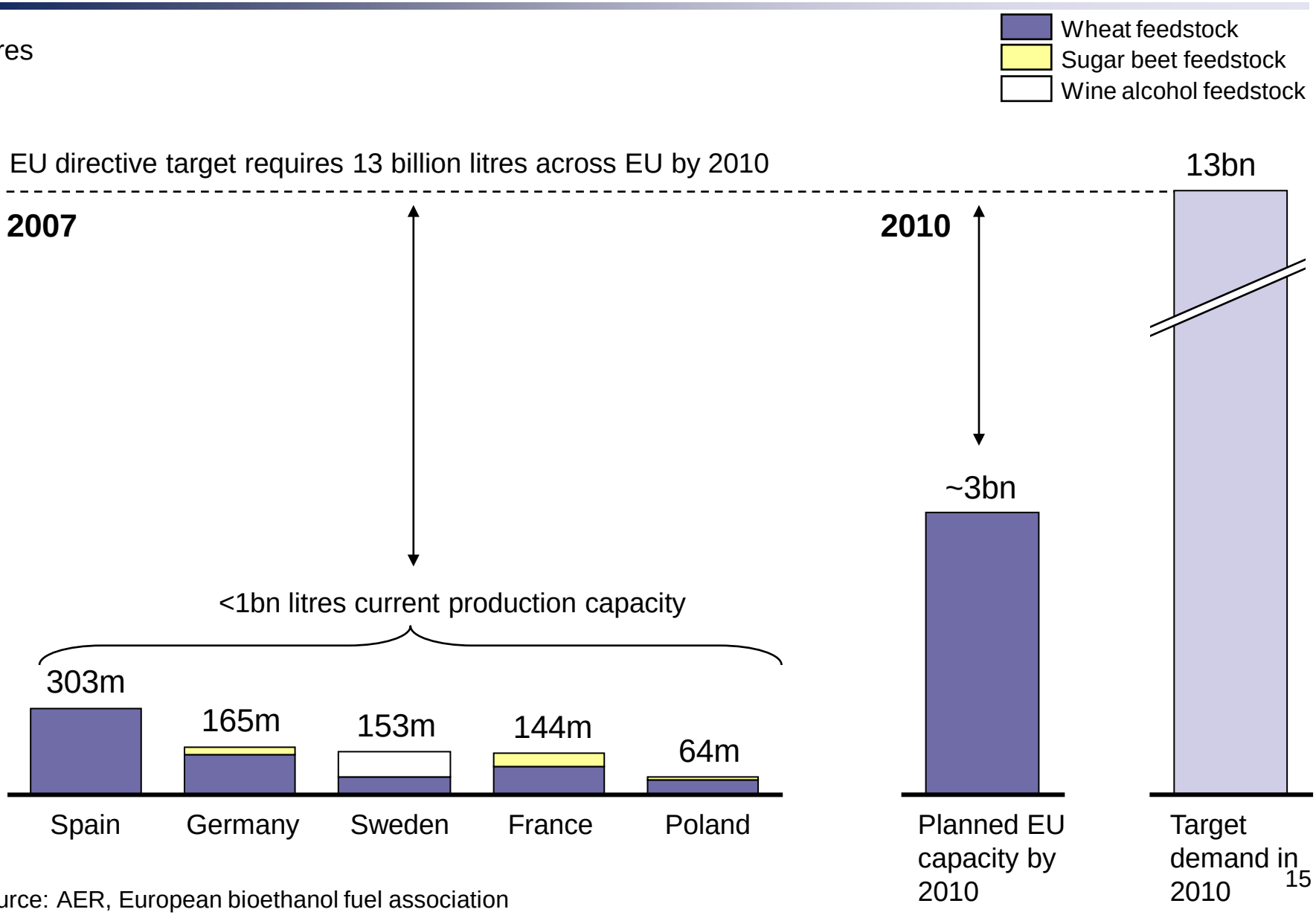
China
- *Today*: 2bn litres
- *Future*: Growth at 10+%

Brazil
- *Today*: 17bn litres
- *Future*: Growth at 10+%

Global annual growth forecast at 11% by the IEA

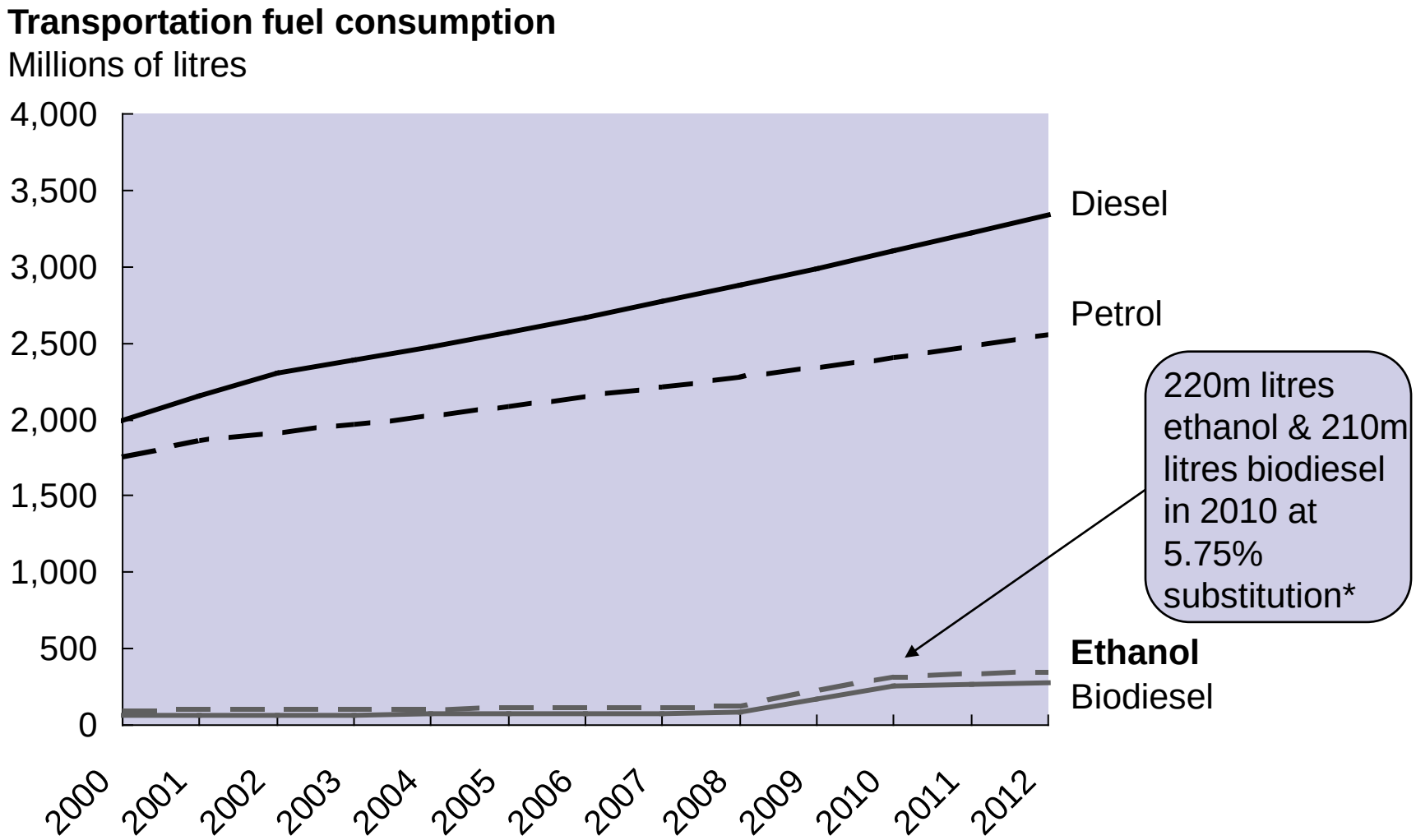
Source: AER, Renewable fuels association, European bioethanol fuel association, McKinsey

International ethanol production falls short of medium term demand targets, creating an opportunity for new plants



Source: AER, European bioethanol fuel association

The market for biofuels in Ireland will grow to meet EU and Irish government targets

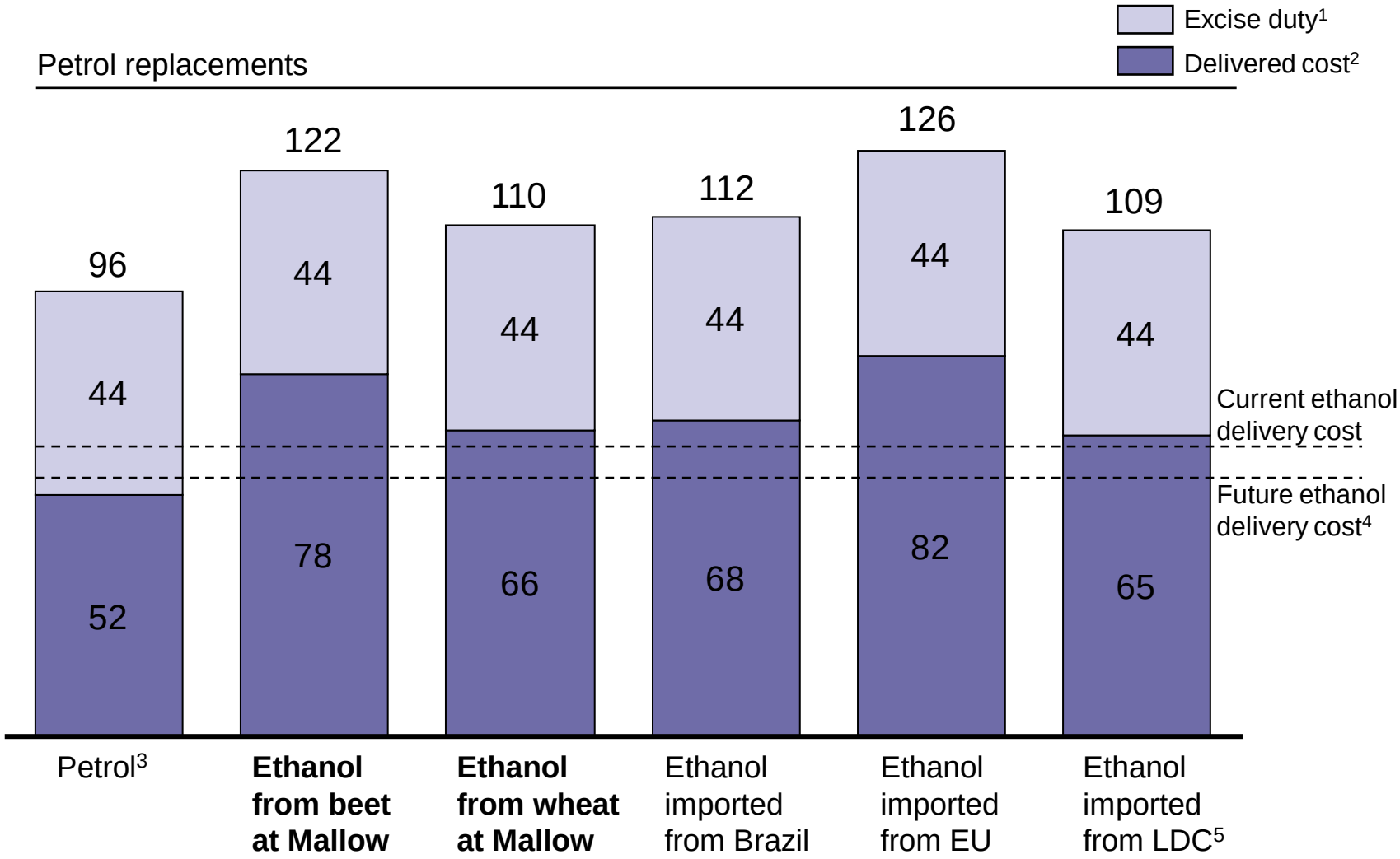


* 5.75% EU biofuels directive target. Ethanol has a lower relative energy content than biodiesel and, therefore, more ethanol is needed on a volumetric basis to replace the same amount of fossil fuel

Source: AER, International Energy Agency, Sustainable Energy Ireland

Relative fuel costs (excluding VAT)

cents/ litre



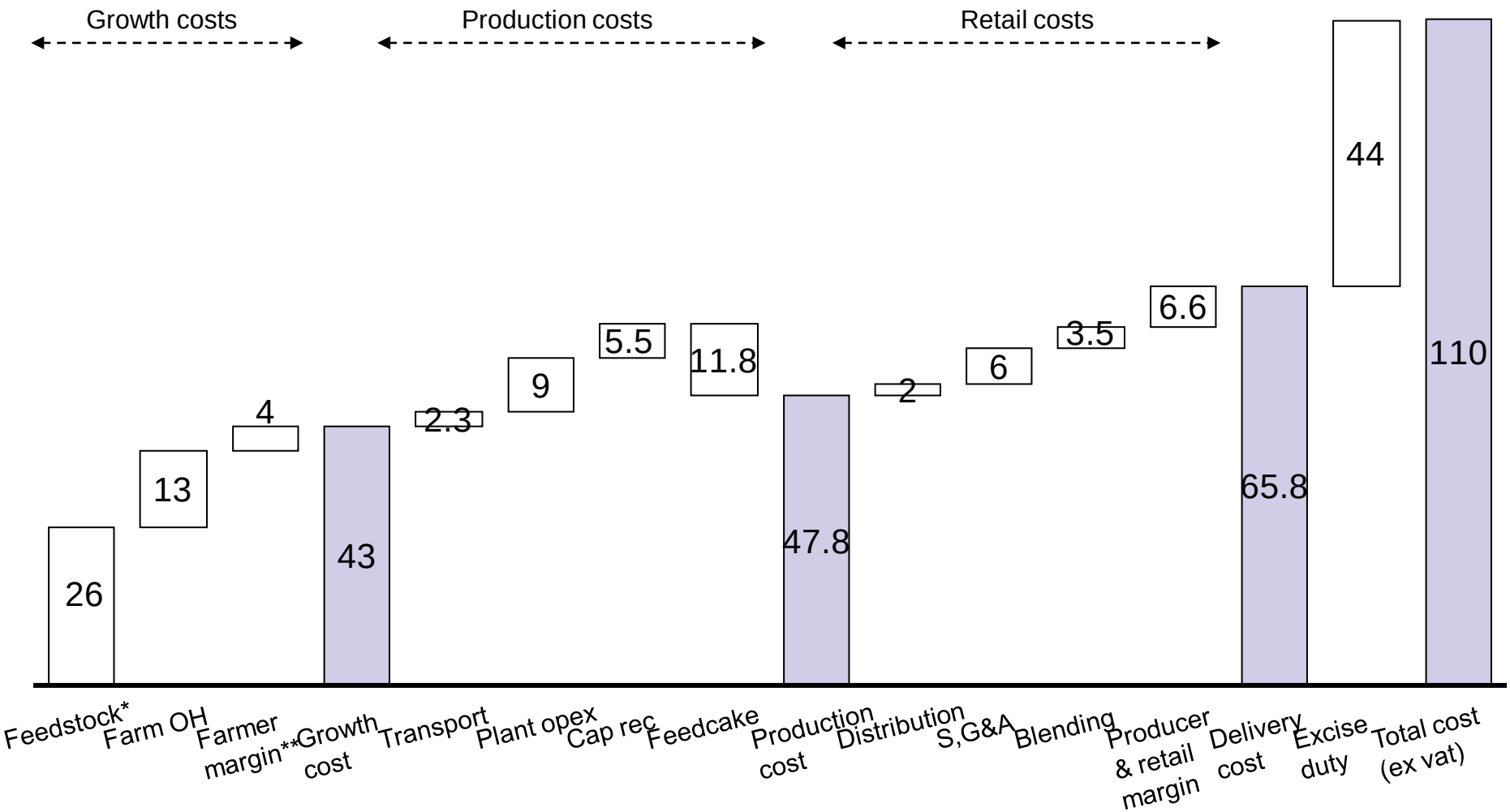
1. Does not include contribution to national oil reserve (~.5ct/ l); 2. Includes production or import cost, capital recovery, distribution, overheads, blending, retail margin; 3. Pump price July 2006; 4. Chicago board of trade ethanol futures: July 2006 to July 2007, cross referenced with local brokerage prices; 5 Least developed country, no import duty applies, i.e., Mozambique

Source: Ecofys, SEI, IFA, Teagasc, CBOT

Ethanol produced from wheat at Mallow

Cost components

cent/ litre

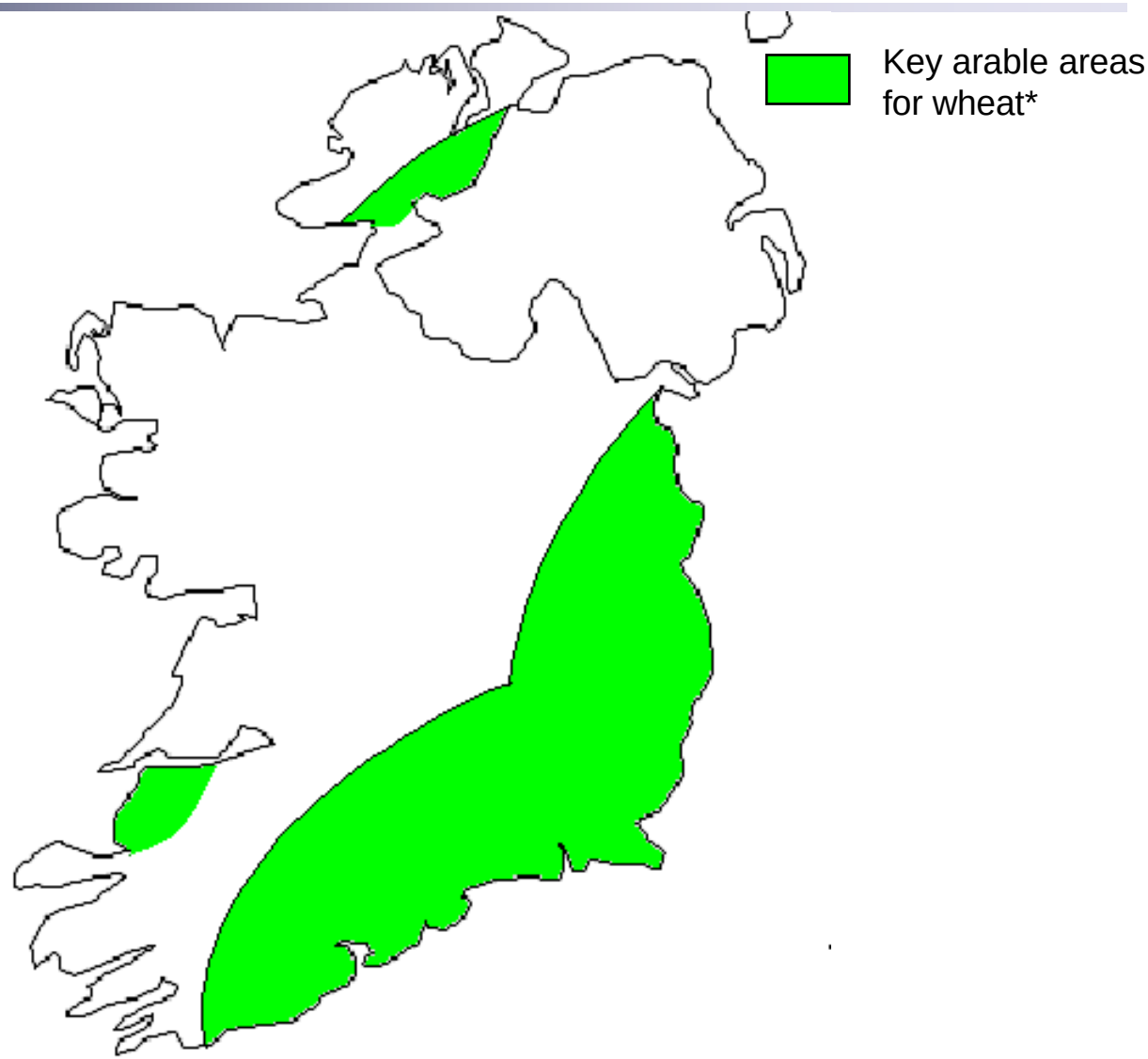


* Includes variable farm costs, net of carbon premium, ** Farmer margin assumes price for wheat is circa 145 euro/tonne

Source: Ecofys, IFA, Teagasc, SEI

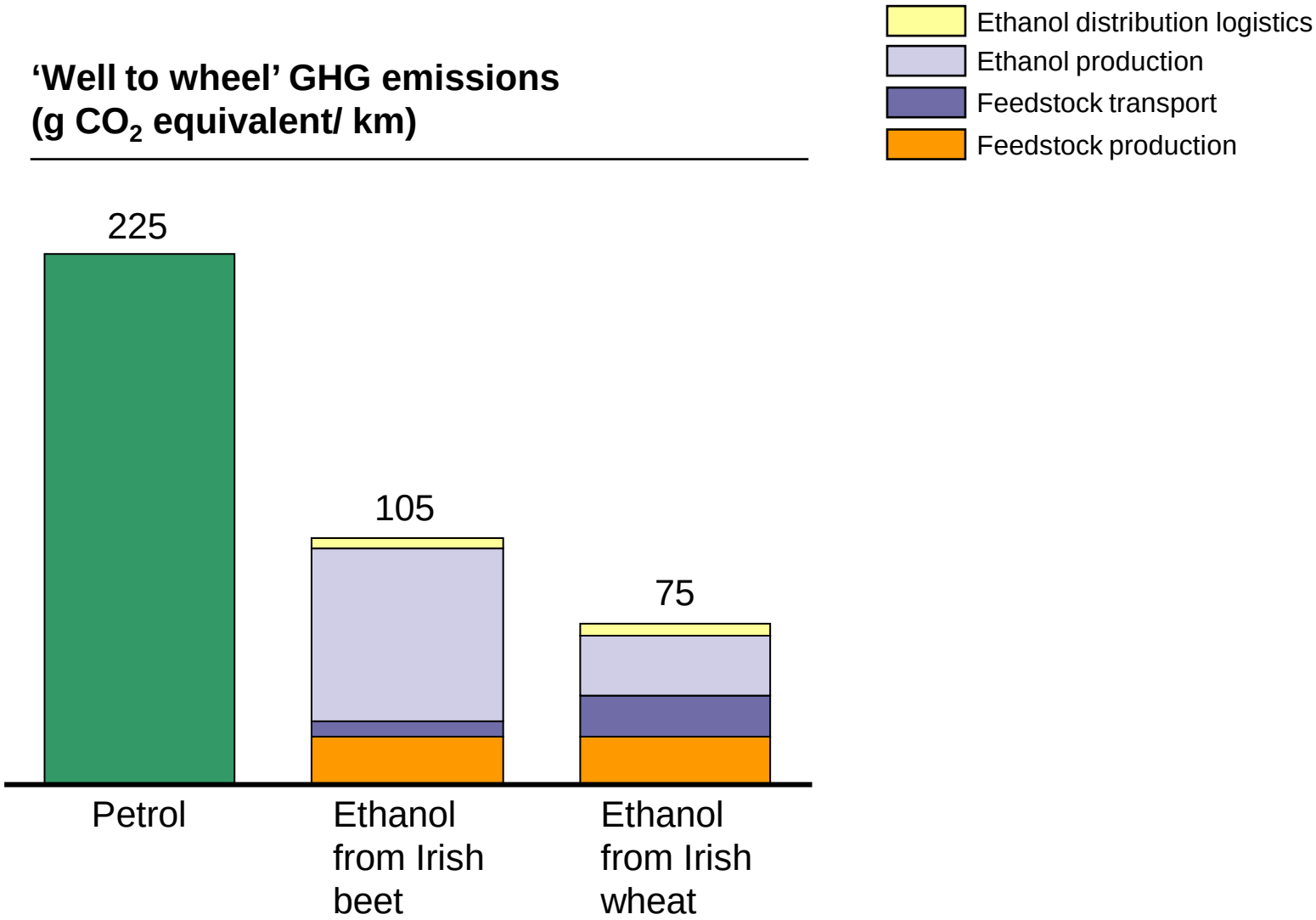
Feedstock and land required for a large scale ethanol plant

- 420,000 tonnes of wheat would be required for a 150m litre plant
- 50,000 hectares would be required to grow this wheat
- Teagasc estimates that 78,000 hectares are available for bioenergy crops by using set-aside and grass lands (i.e., no displacement of food)
- An additional 40,000 hectares are available as a result of the cessation of sugar beet growing



* These agricultural areas are also used for dairying, sheep and dry stock
Source: AER, Teagasc, Sustainable Energy Ireland (SEI)

Green house gas emissions for petrol and ethanol



Source: AER

Suggested focus of research themes and future growth of the Biorefinery and Bioenergy Competence Centre

Horizons of growth for the Competence Centre

Launch
2008 - 2009

- Research theme 1: Next generation feedstock analysis
  - Optimal culturing and use of grass (major) and algae (minor)
- Research theme 2: Conversion technology
  - Enzymatic conversion of feedstock to fuels and biorefinery co-products

Grow
2009 - 2011

- Selected complementary research themes on feedstock (e.g., municipal solid waste; wood); conversion technologies and biorefining
- Irish and international (bio)energy, industrial and pharmaceutical companies start to commercialise technology

Expand
2010 - 2012

- Potential pilot plant for validation and commercialisation of feedstock and conversion technology