African Caribbean and Pacific Group of States
Science and Technology Programme

Sustainable non-food sources of biofuels

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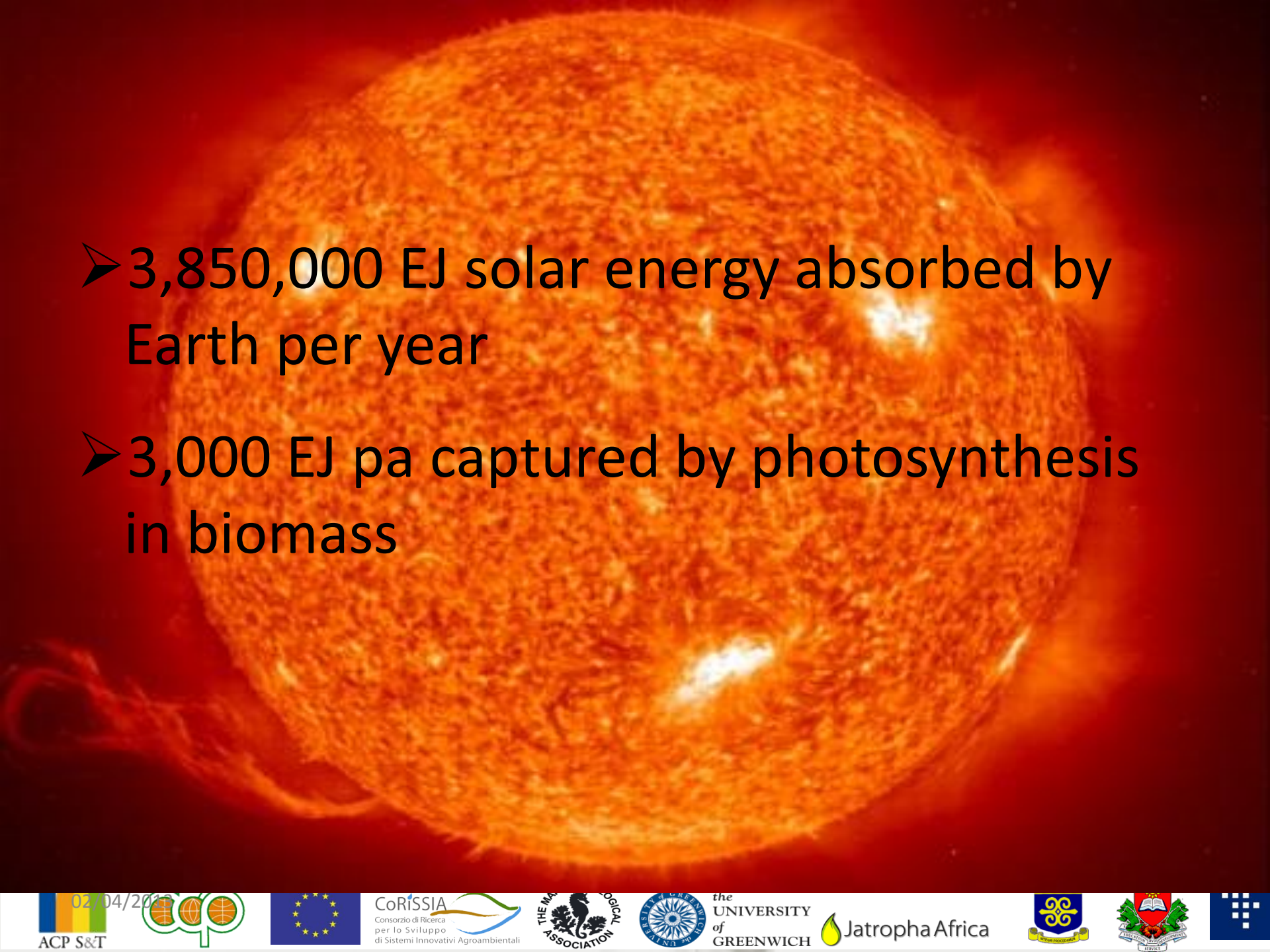
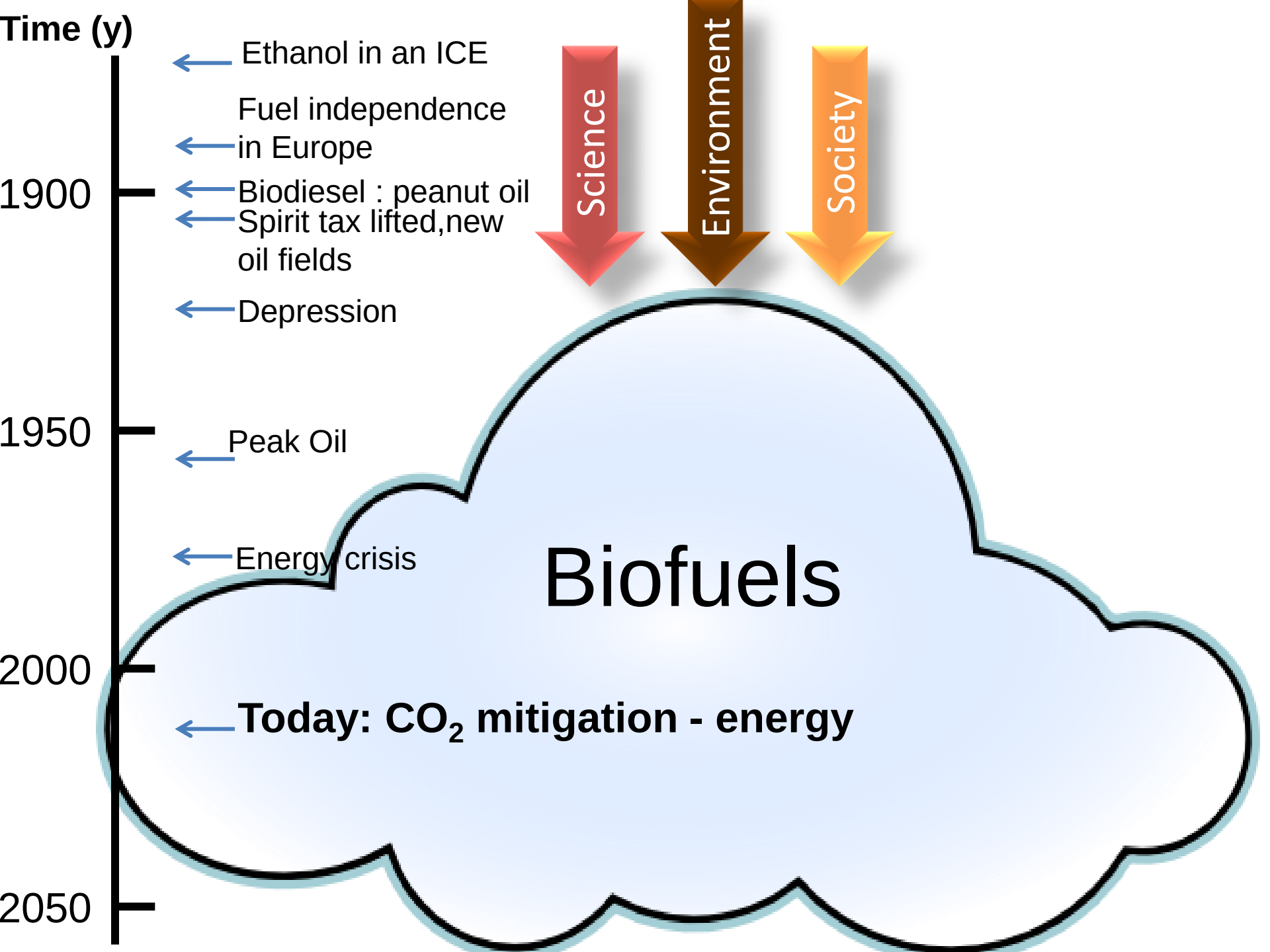
2 April 2013



- 3,850,000 EJ solar energy absorbed by Earth per year
- 3,000 EJ pa captured by photosynthesis in biomass

1. BIOFUELS ARE NOT NEW

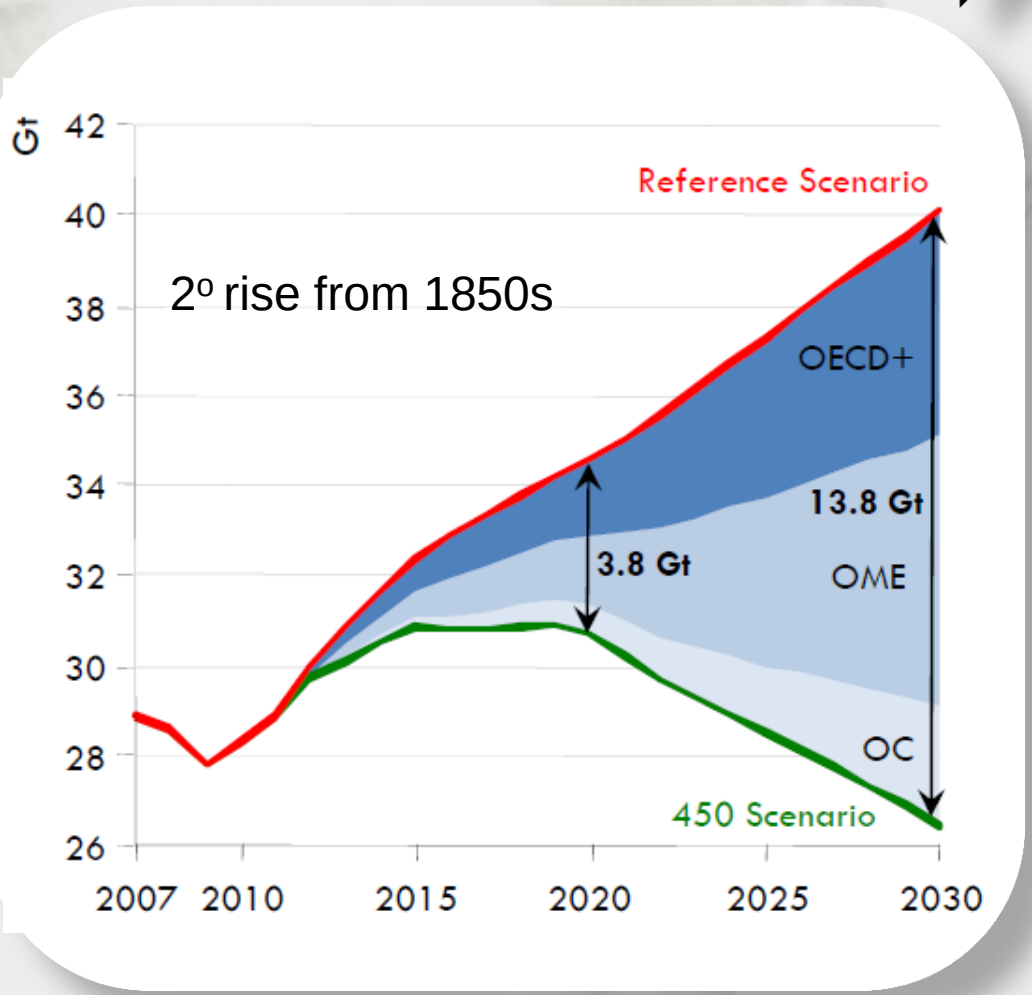

Time (y)
Ethanol in an ICE
Fuel independence in Europe
Biodiesel : peanut oil
Spirit tax lifted,new oil fields
Depression
Peak Oil
Energy crisis
Today: CO_2 mitigation - energy
1900
1950
2000
2050
Science
Environment
Society
Biofuels

Executive Director of the IEA Nov 2009

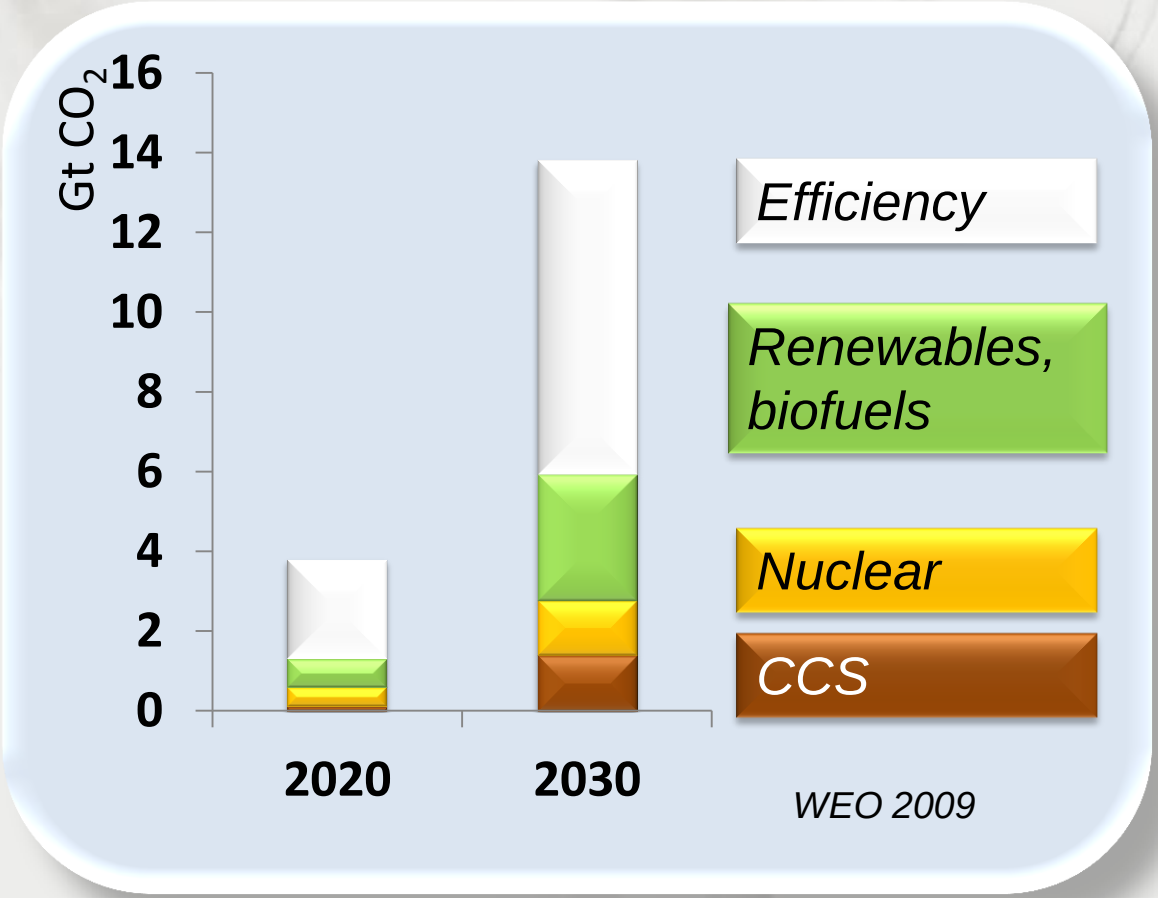
If the world continues on the basis of today's energy policies, the climate change impacts will be severe.

Energy which accounts for two-thirds of today's GHG emissions is at the heart of the problem: and so must form the core of the solution

CO_2 emissions -climate change

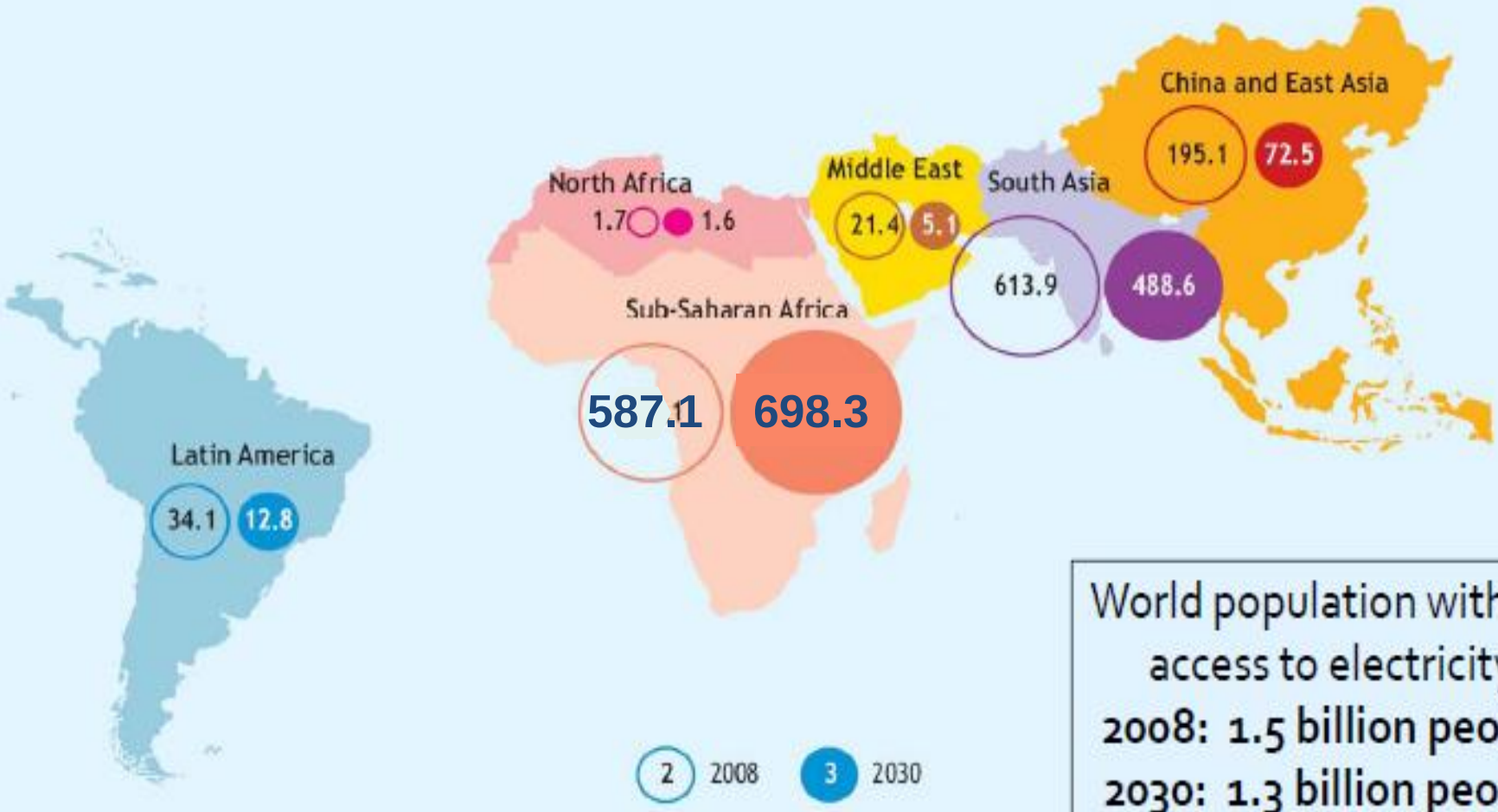


CO_2 emissions -climate change



2. THE ENERGY PROBLEM TODAY

Number of people without access to electricity in the Reference Scenario (millions)

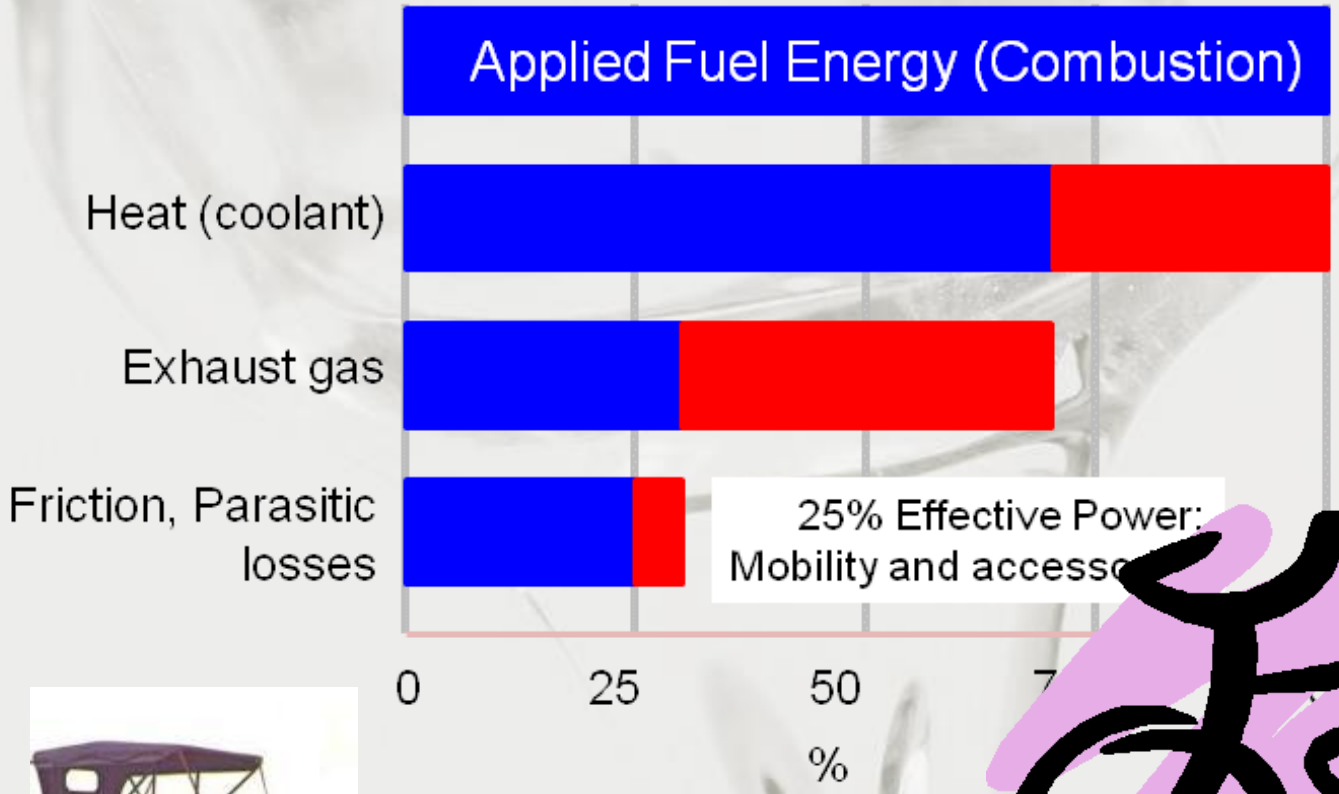


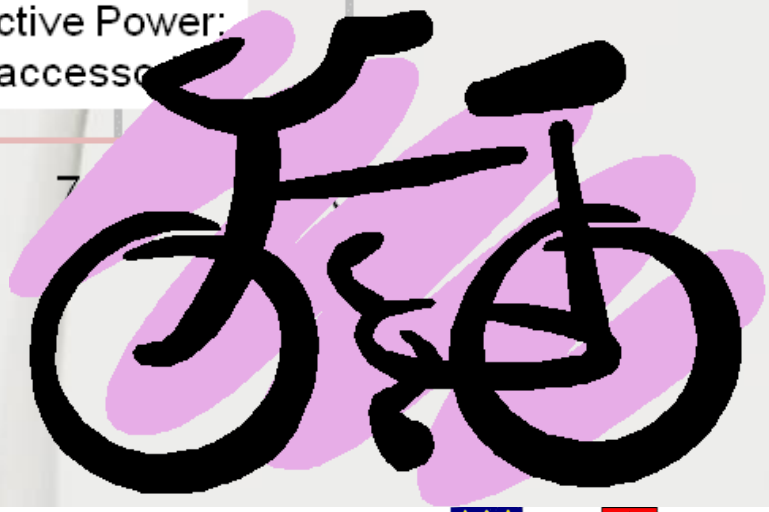
World population without access to electricity
2008: 1.5 billion people
2030: 1.3 billion people


San Francisco


Beijing

Automotive Internal Combustion Engines






Namibia

Energy conversion efficiencies

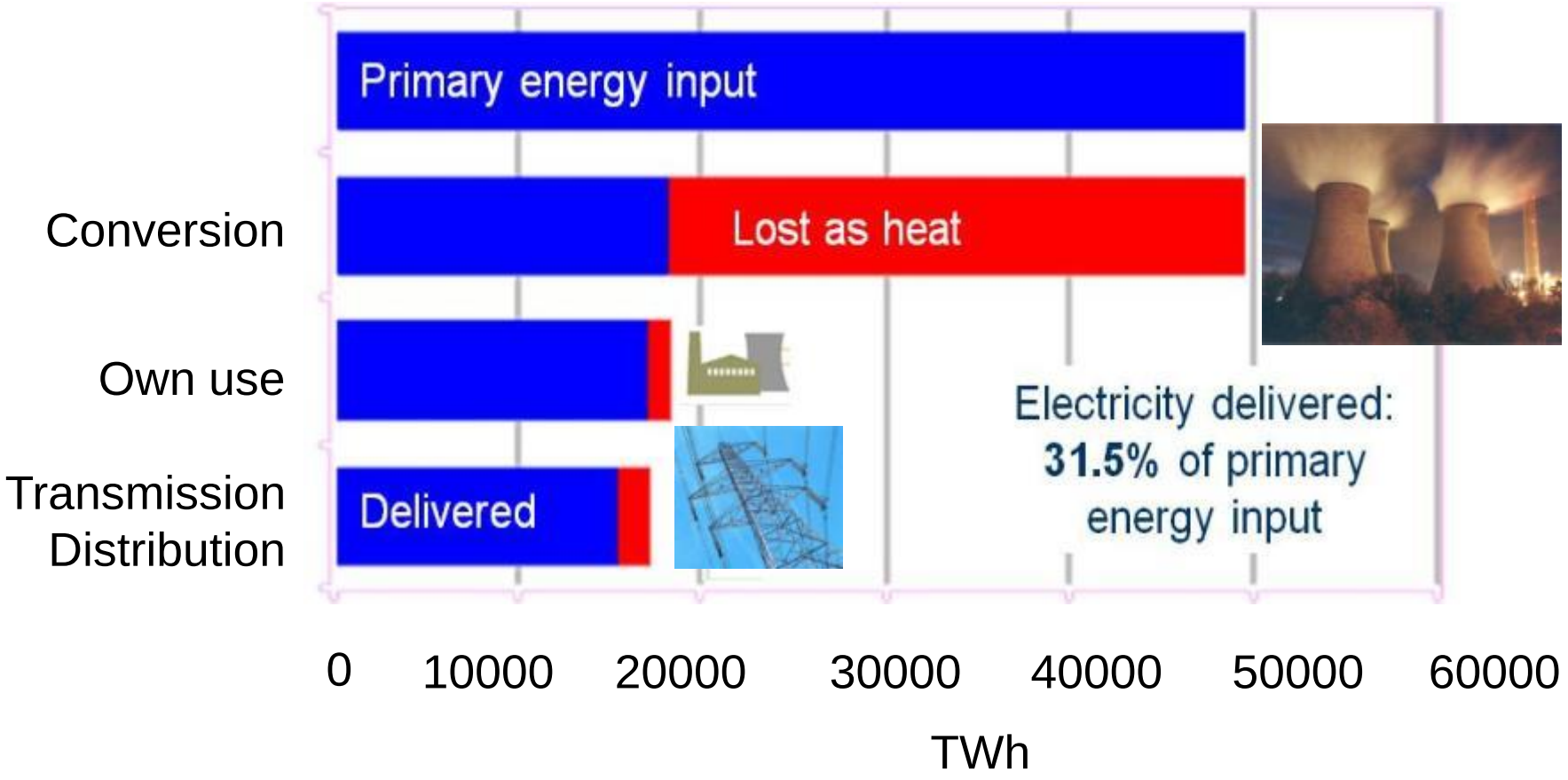
Conversion	Efficiency %	Input
Electrical motor	90-97	Electricity through grid
Small electric motor	60-75%	Electri
Steam turbine 40-45%	40-45%	Steam
Gas turbine	35 - 40%	Gas
Diesel ICE	30-35%	Diesel
Petrol ICE	15-25%	Petrol
Mammalian muscle	15-20%	Glucose

Zhang (2011): Process Biochemistry 46, 2091-2110

The risk

Losses in global energy conversion and power delivery

Source: IEA 2008



3 BIOFUELS AND TECHNOLOGIES

1st generation feed-stocks





Peanut oil *Soy bean* *Sunflower* *Rapeseed* *Palm*

Oil –> biodiesel

38kJ/g

Starch, sugars –> bioethanol

27kJ/g




Sugar beet *Sugar cane* *Corn -maize* *Wheat*

2nd generation feed-stocks

Non-food oil

Jatropha

Straw

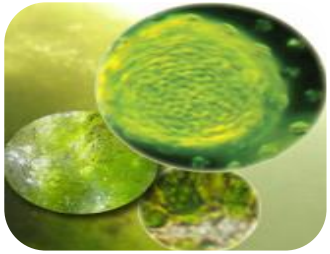
Miscanthus

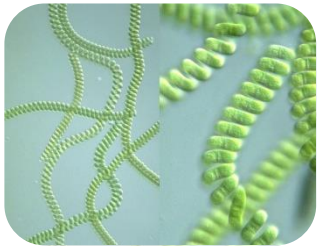
Willow

Wood

Lignocellulosics

Food waste





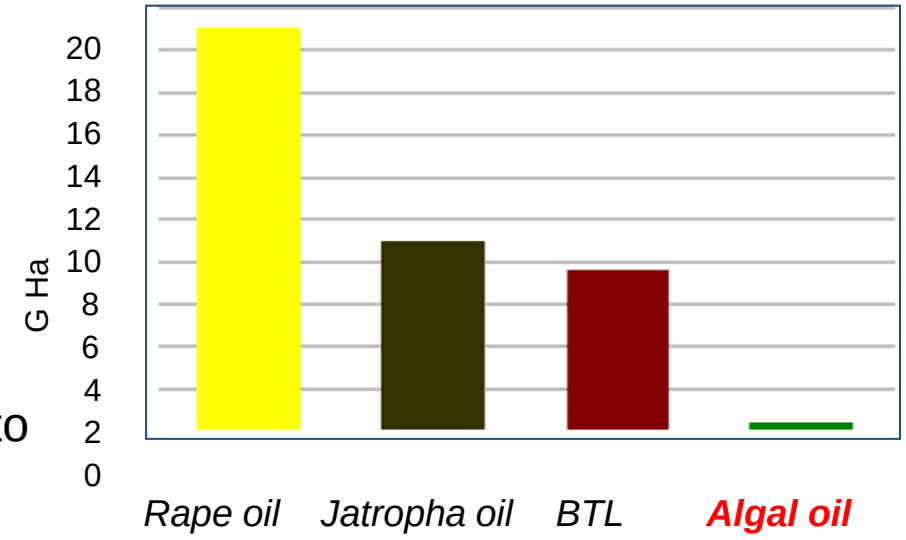

Microalgae

Algae

Macroalgae

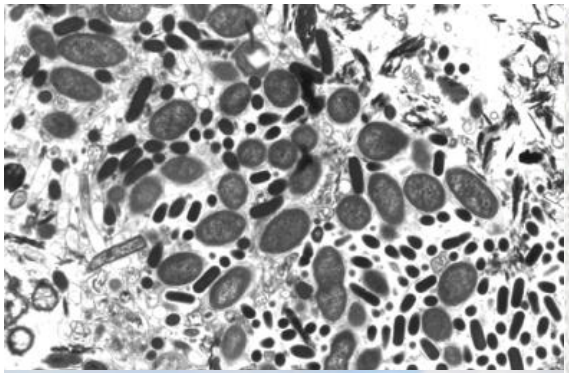
- High productivity potential: Biomass doubling times in h
- >1000 species, infinite strains, all habitats

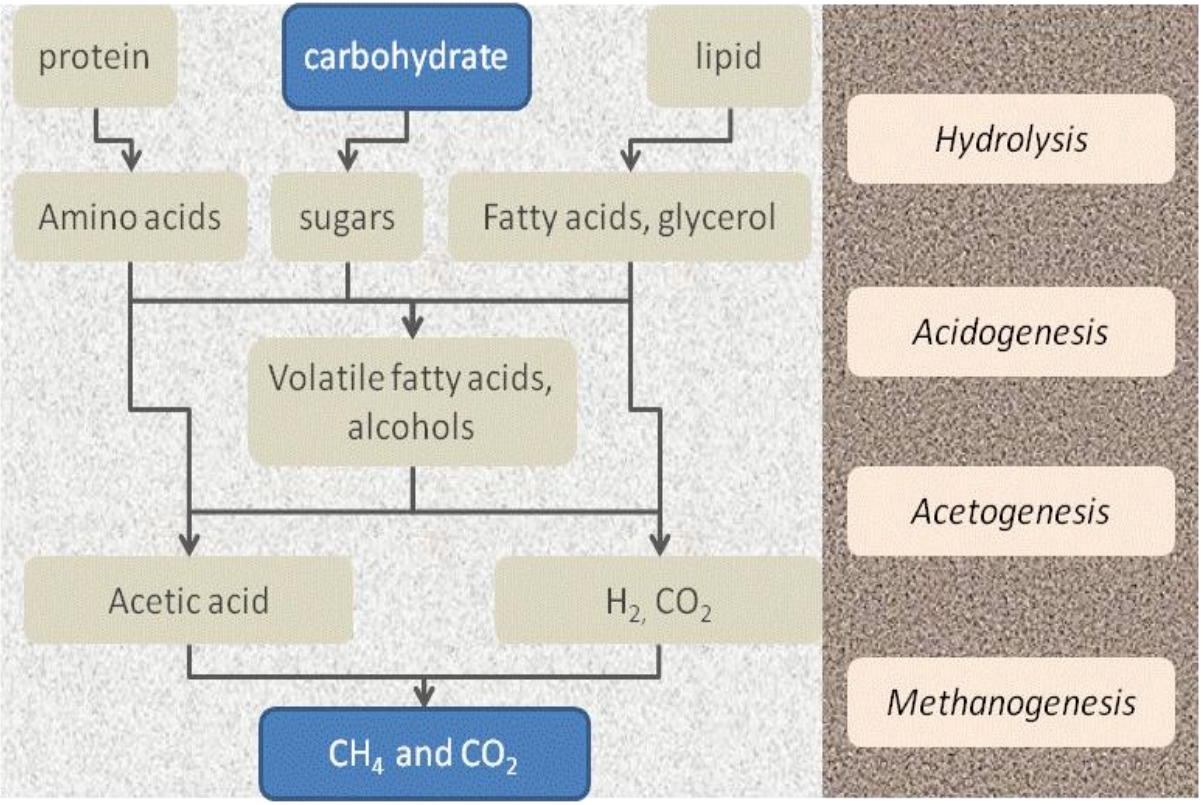
Land needed for biofuel feedstocks to meet 2009 global fossil energy use



2nd generation technologies

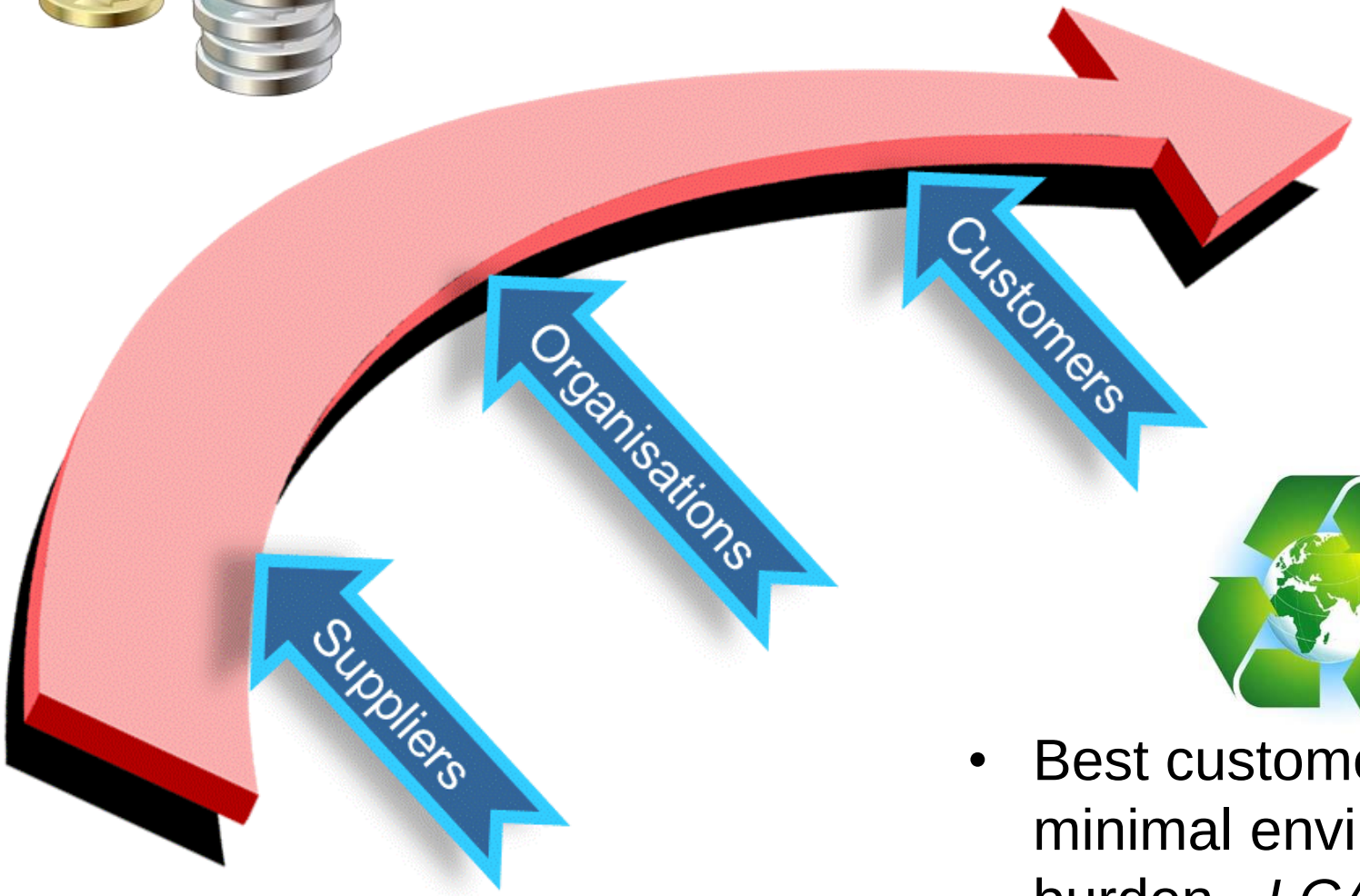
- Anaerobic digestion → biogas (*methane, CO_2*)





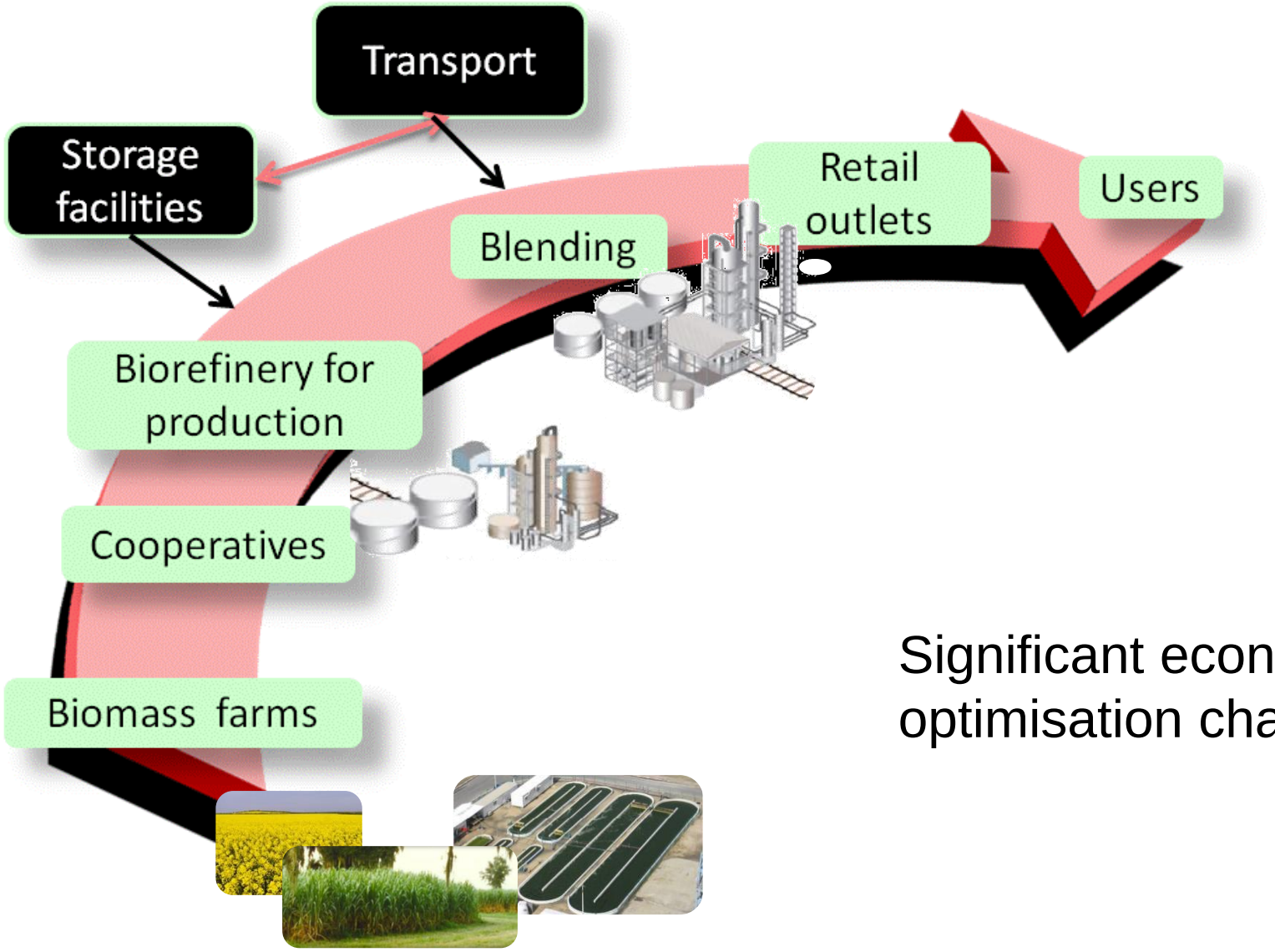
5. THE TOUGH NUTS TO CRACK

- Best customer value at lowest cost – *economic assessment*



- Best customer value with minimal environmental burden - *LCA*

The difficult part is the Biofuel Supply Chain



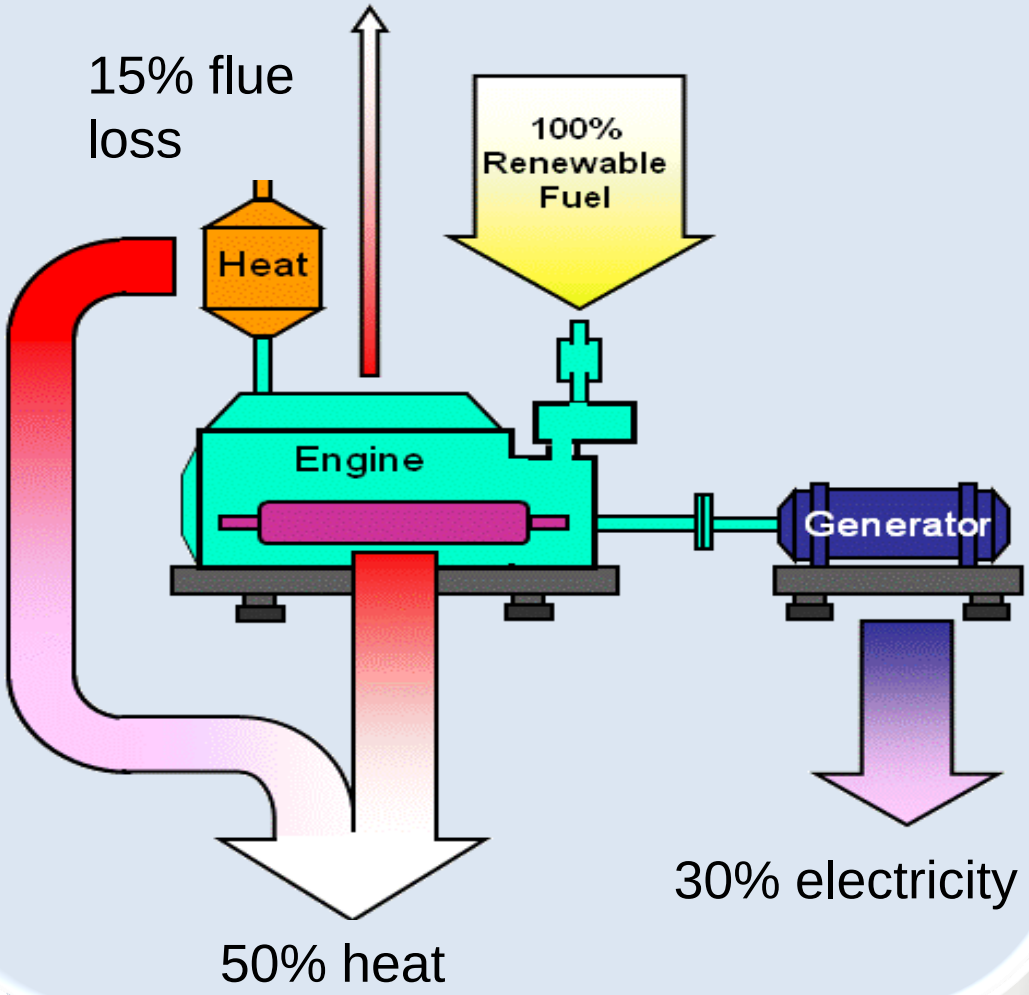
Significant economic optimisation challenges

ACP

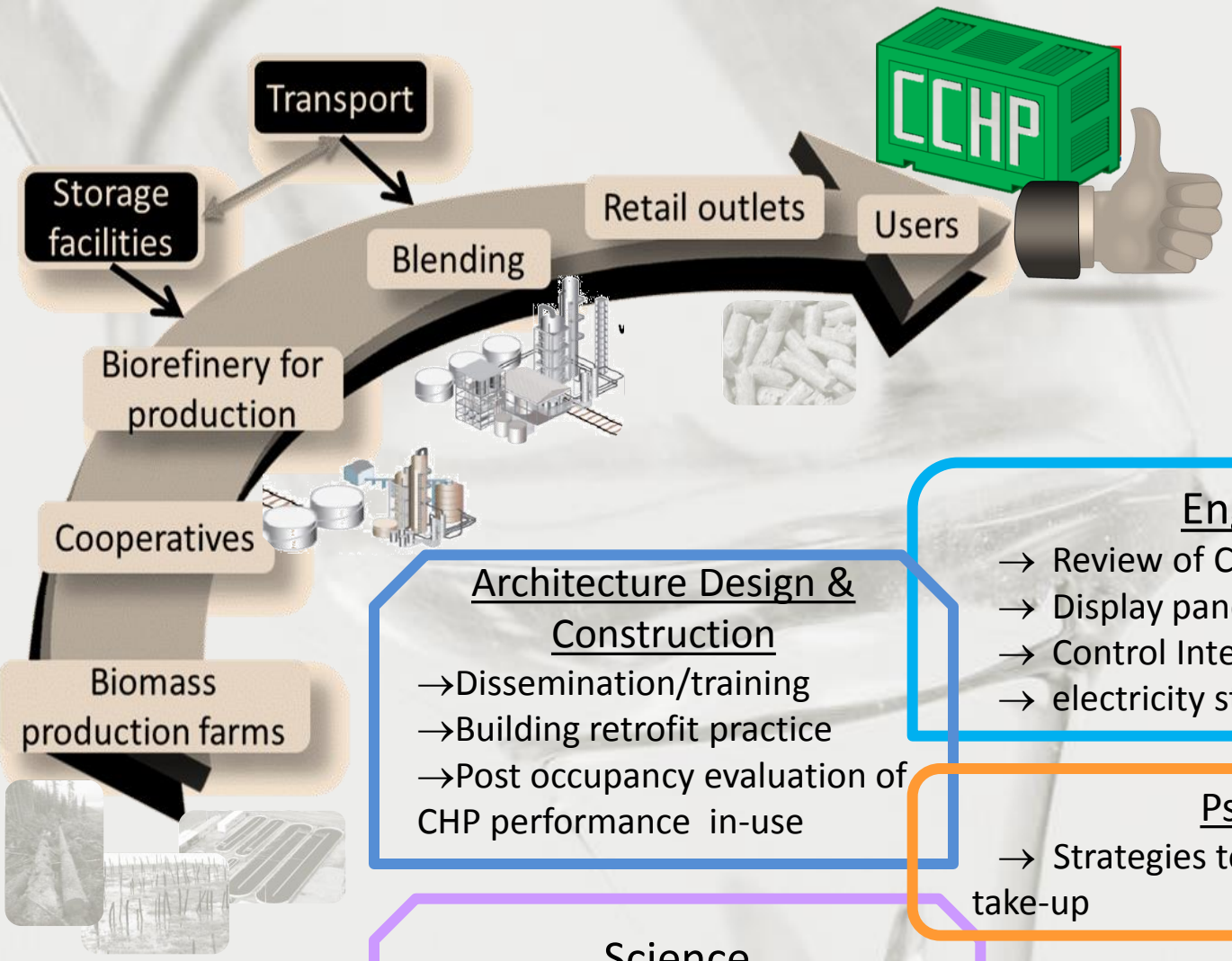
- *'EC's Strategy for Sustainable Development'*
- Build, enhance scientific & technological capacity for R&D & innovation
- Enable activities /policies critical to sustainable development

This ACP Project

- 36 months
- South Africa, Namibia, Ghana, UK, Italy
- Regional, local authorities, municipalities
  - sewage, water,
  - energy procurement



- Simultaneous generation of heat & power
- Ideal where both heat & power needed



Facilities Management

→ Design, installation & operation of biofuel CCHP

Engineering

→ Review of CCHP design,
→ Display panels,
→ Control Intelligence: power systems
→ electricity storage

Architecture Design & Construction

→Dissemination/training
→Building retrofit practice
→Post occupancy evaluation of CHP performance in-use

Psychology

→ Strategies to encourage biofuel CHP take-up

Science

→ Biofuel Value Chains
→ Environmental footprints
→ Risks

Business

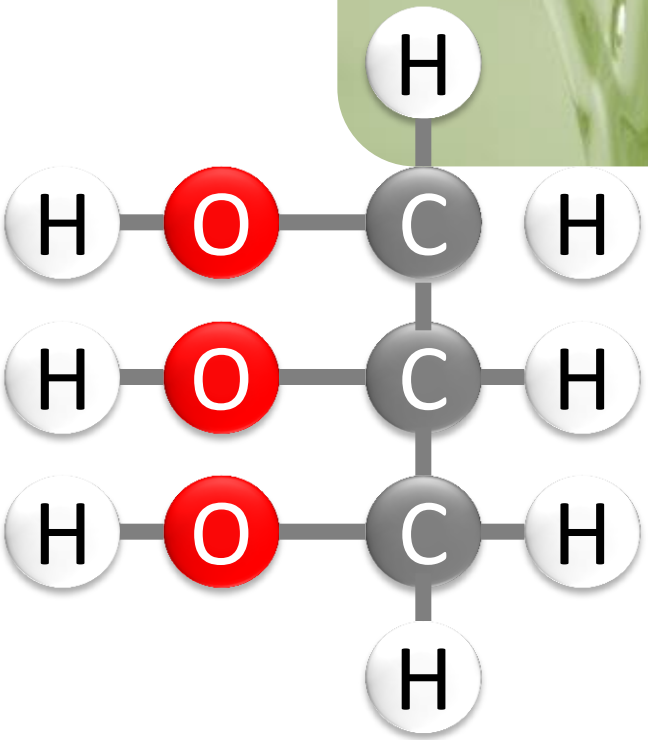
→ Economic footprints
→ Review of business models
→ Business training for CHP adoption

Medway Campus: science, engineering buildings to be served by proposed glyce

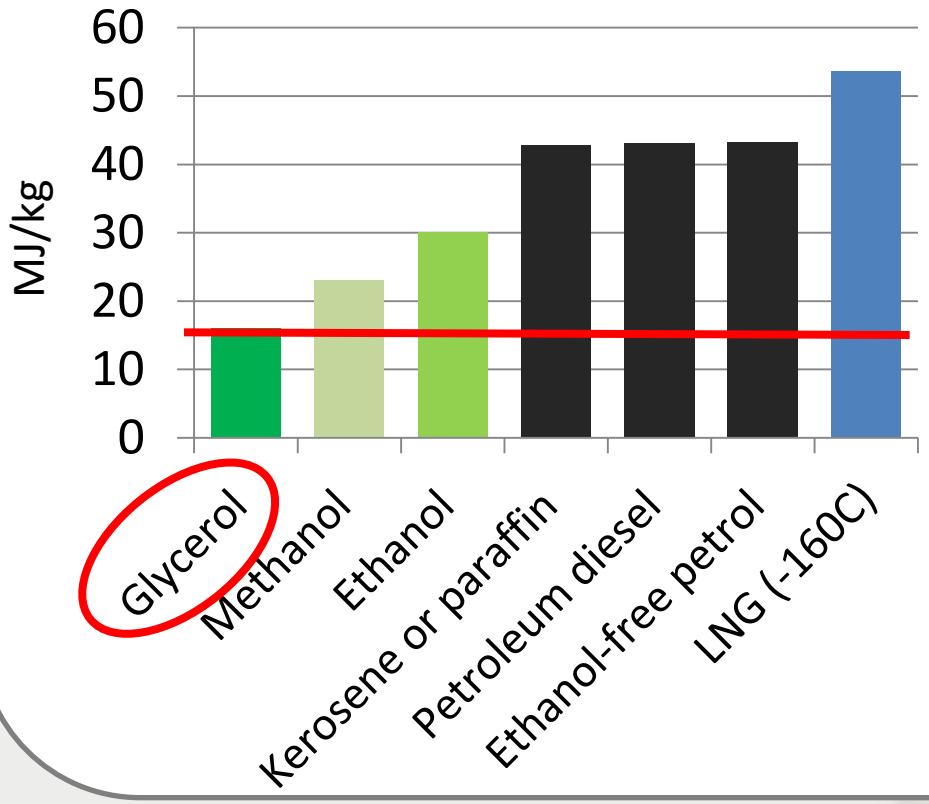
7. A NEW BIOFUEL: GLYCEROL

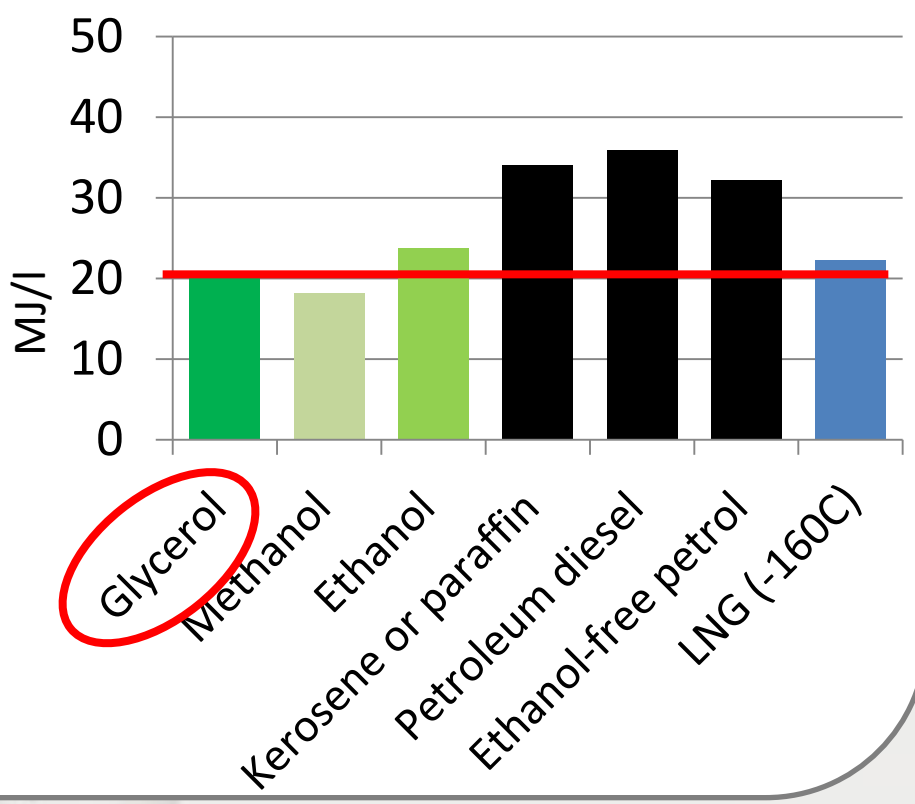
Glycal

- Water-soluble
- Non-flammable
- Non-volatile
- High boiling point
- Bio-production
- Bio-degradable
- No environmental pollution



Energy content of glycerol





High energy conversion efficiency

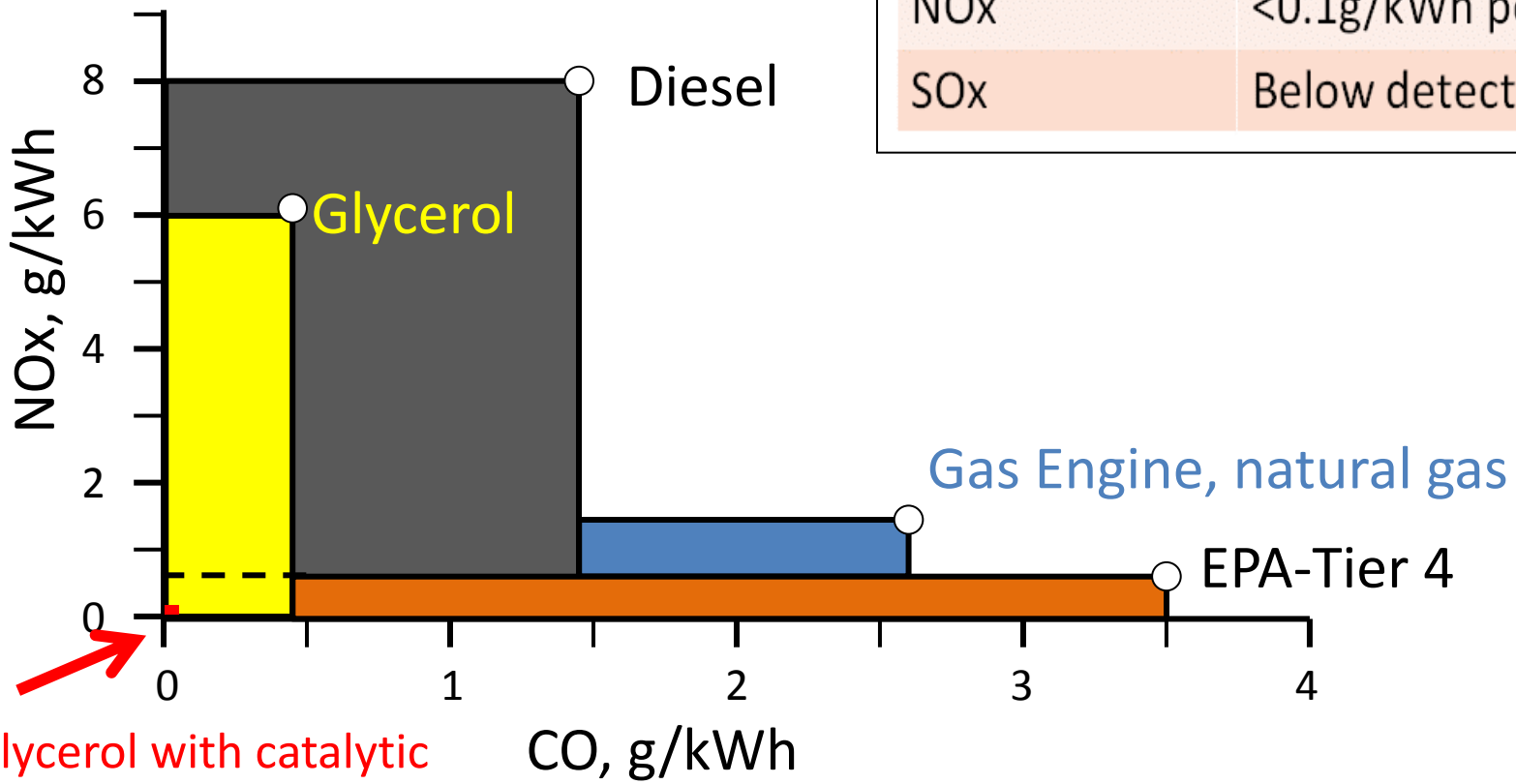
Engine size	Electrical efficiency
10-50 kWe	37%
100-1000 kWe	42%
1000 – 10000 kWe	48%

- No addition of combustion enhancers necessary
- Engine performance with glycerol proven

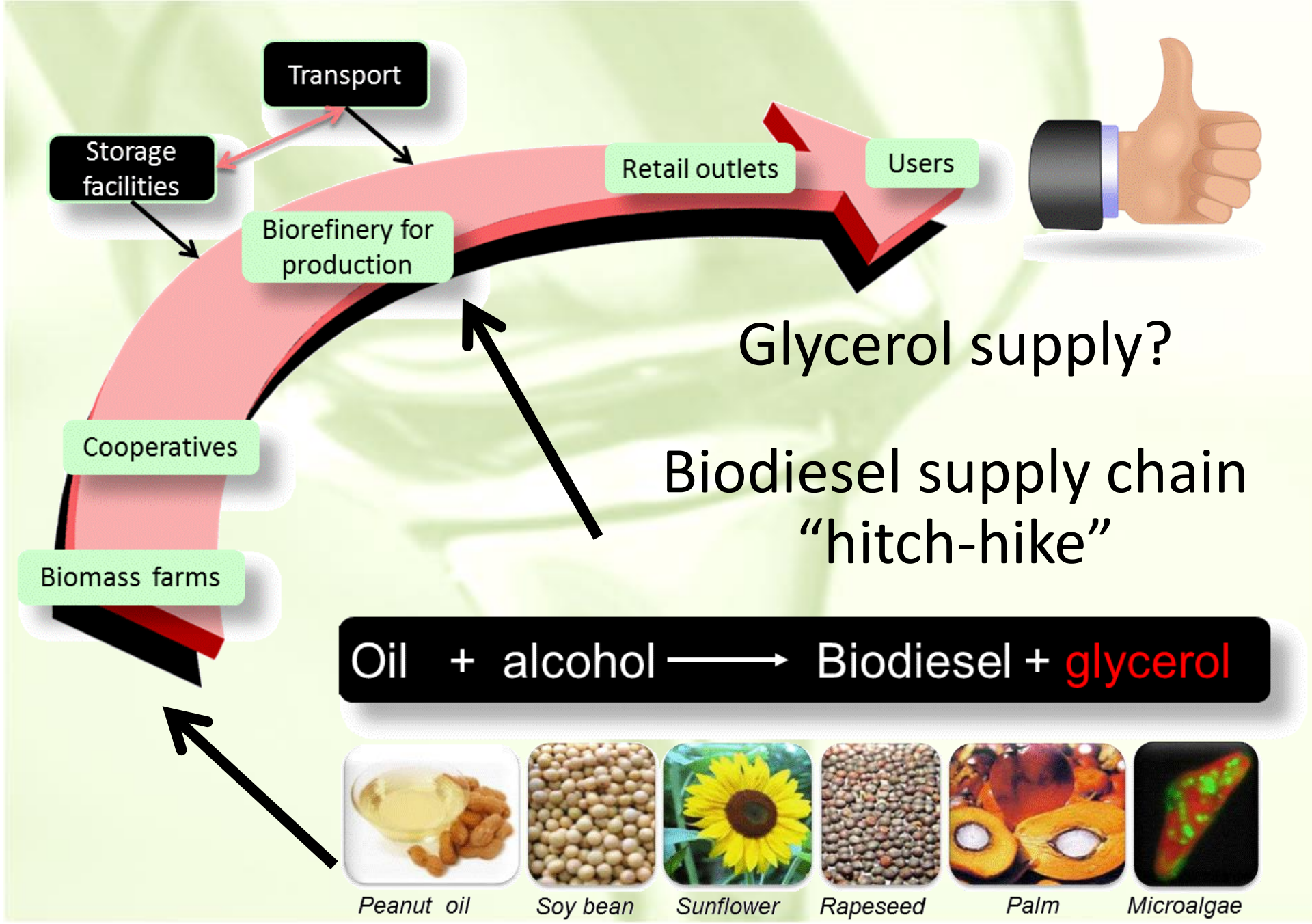
Emissions on combustion

Aquafuel™

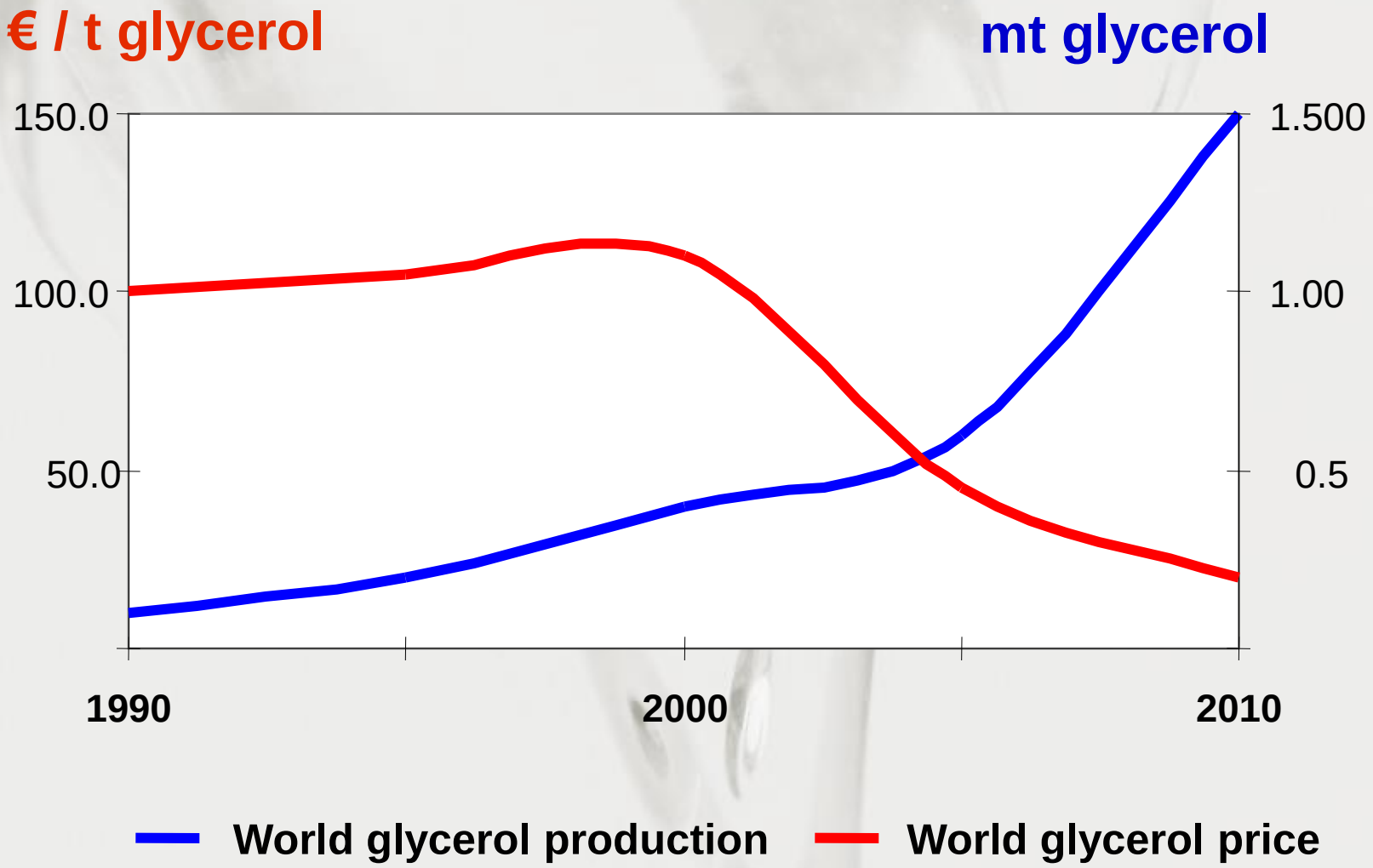
Emissions	Amount
Particulate	Below detection limits
NOx	<0.1g/kWh possible
SOx	Below detection limits



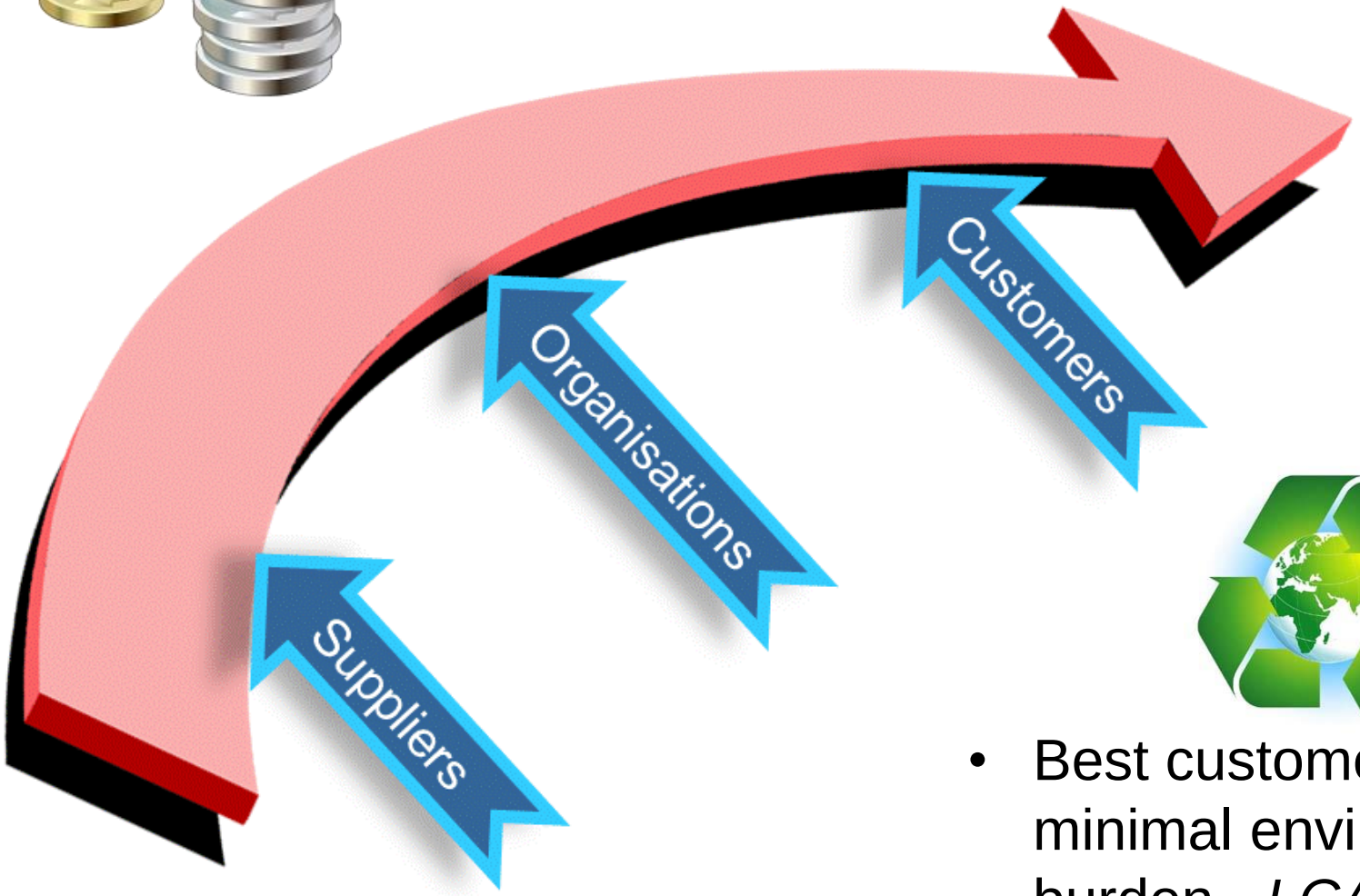
Independently verified


Transport
Storage facilities
Biorefinery for production
Retail outlets
Users
Cooperatives
Biomass farms
Glycerol supply?
Biodiesel supply chain "hitch-hike"
Oil + alcohol ⟶ Biodiesel + glycerol
Peanut oil
Soy bean
Sunflower
Rapeseed
Palm
Microalgae

Glycerol market



- Best customer value at lowest cost – *economic assessment*



- Best customer value with minimal environmental burden - *LCA*

Can Glycerol costs come down? – perhaps from algae?

	Glycerol CHP	Gas CHP
CO_2 savings (tonnes pa)	~2,000	~500
Costs pa	+ £270,000	-£60,000

- Forecast reduction in glycerol price from circa 10p/kWh to around 7p/kWh, as a consequence of additional refinery capacity
- Glycerol CHP would still be marginally more expensive to operate than the current arrangements.

Glycerol from microalgae

Dunaliella sp

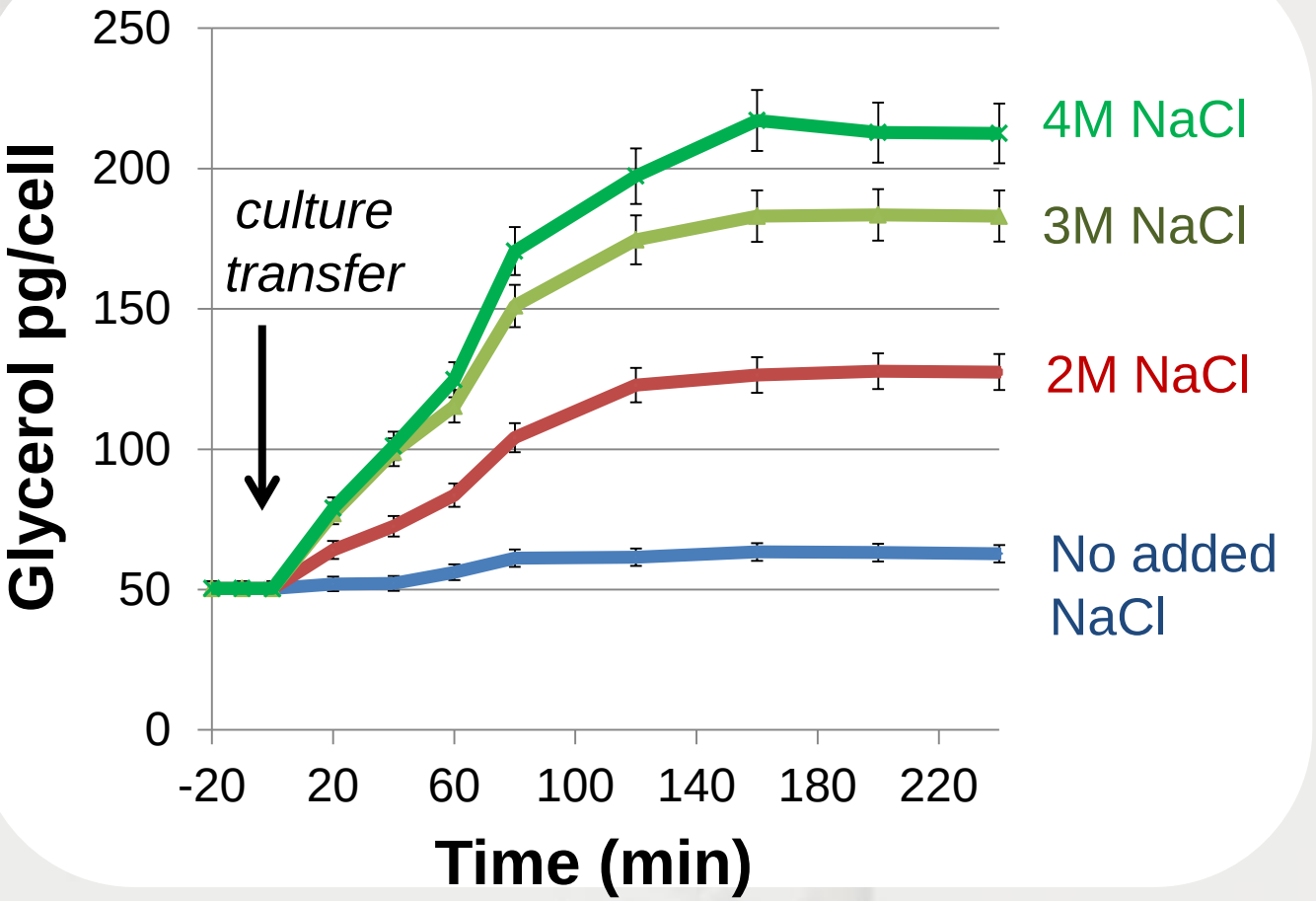
- Halophyte
- ~50-85% biomass (dw) as glycerol
- Biomass doubling time in h
- *A Ben-Amotz:* ~40 tons glycerol d^{-1} km^{-2}

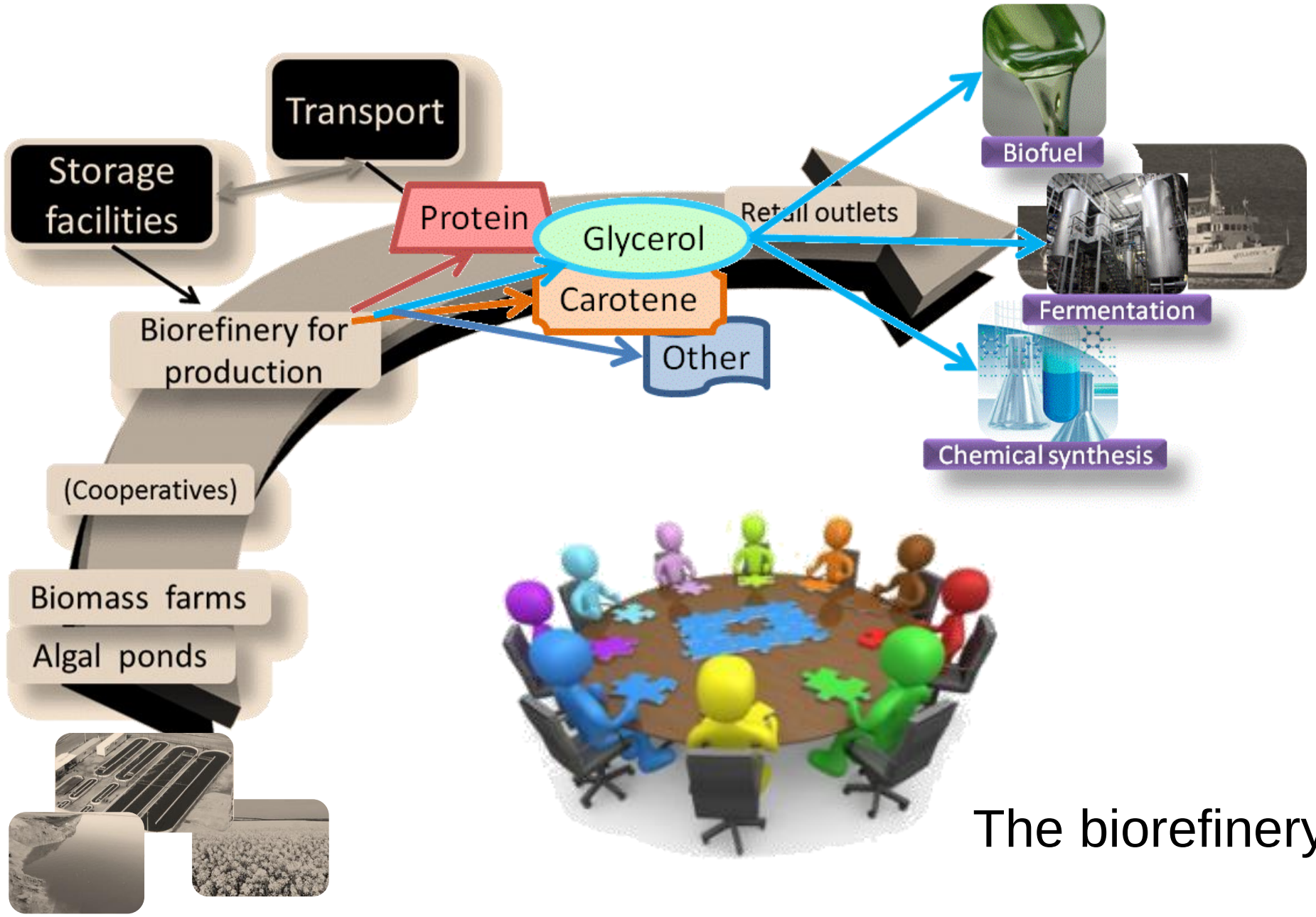
1st Energy Crisis 1975, Glycerol Algal Farm, 500 hectares in Sinai


NBT Eilat


• Productivity
• CO_2 source, nutrients
• Lake / raceway
• Seasonality/cropping
• Energy inputs
• Ecosystem

Glycerol synthesis in response to osmotic shock





The biorefinery