Biofuel Supply Chains

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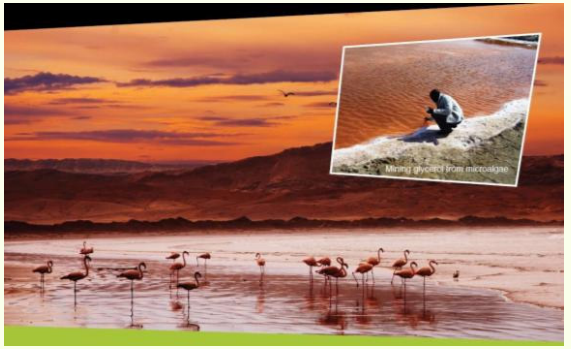
Two scenarios:

- Electricity, desalination, sterilisation for remote communities: biofuel-CHP

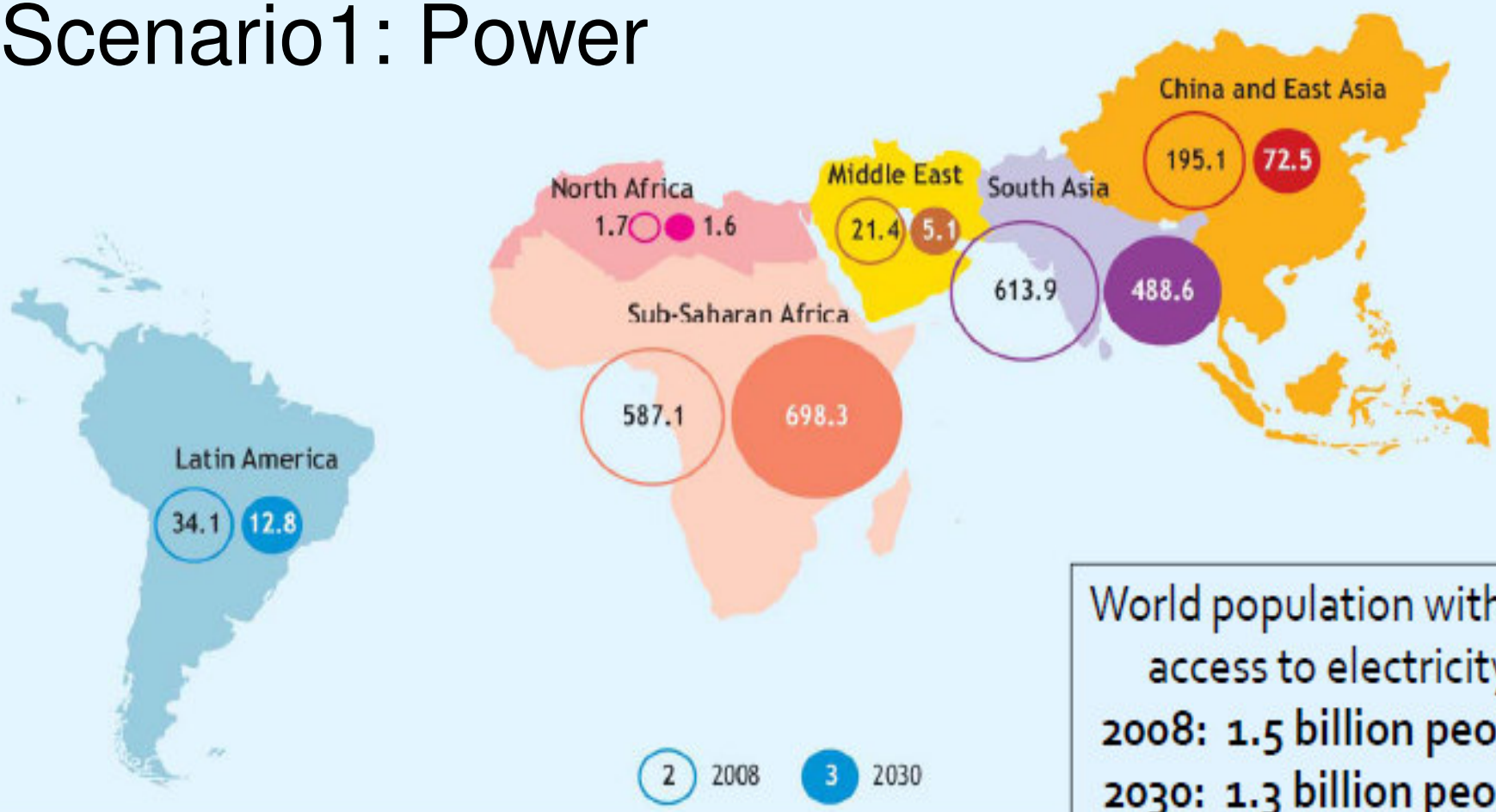
- Transport - marine auxiliary power: glycerol-CHP



World Energy Outlook 2009

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

Scenario1: Power

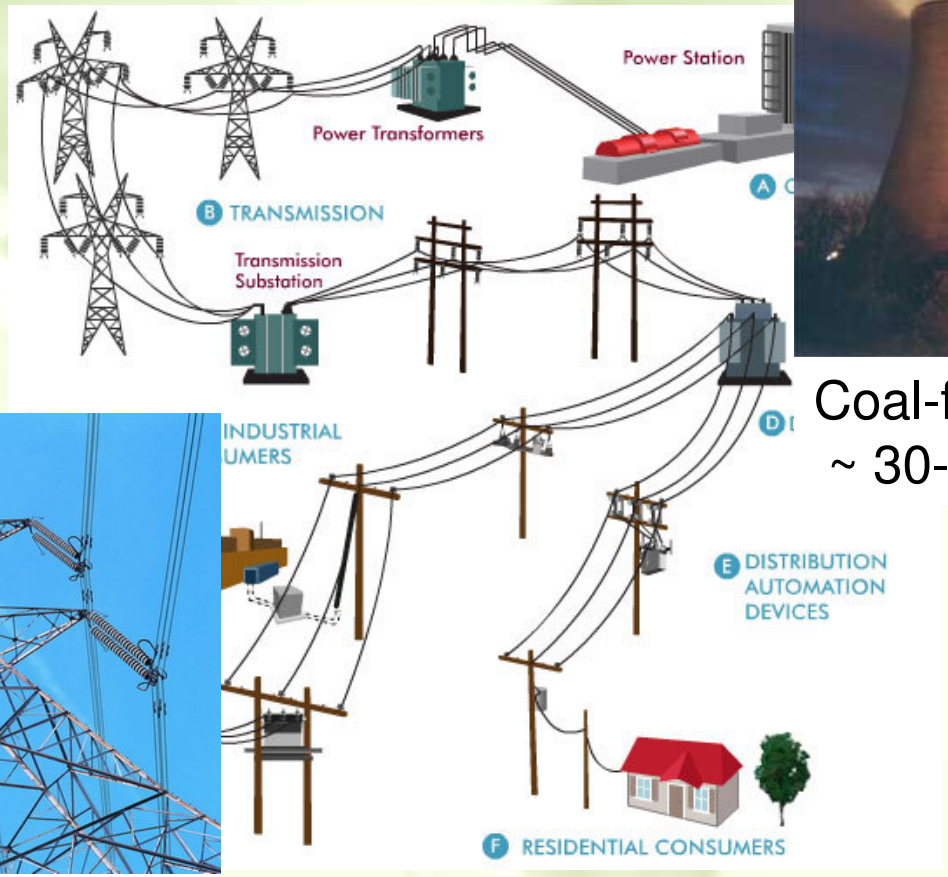


World population without access to electricity

2008: 1.5 billion people

2030: 1.3 billion people

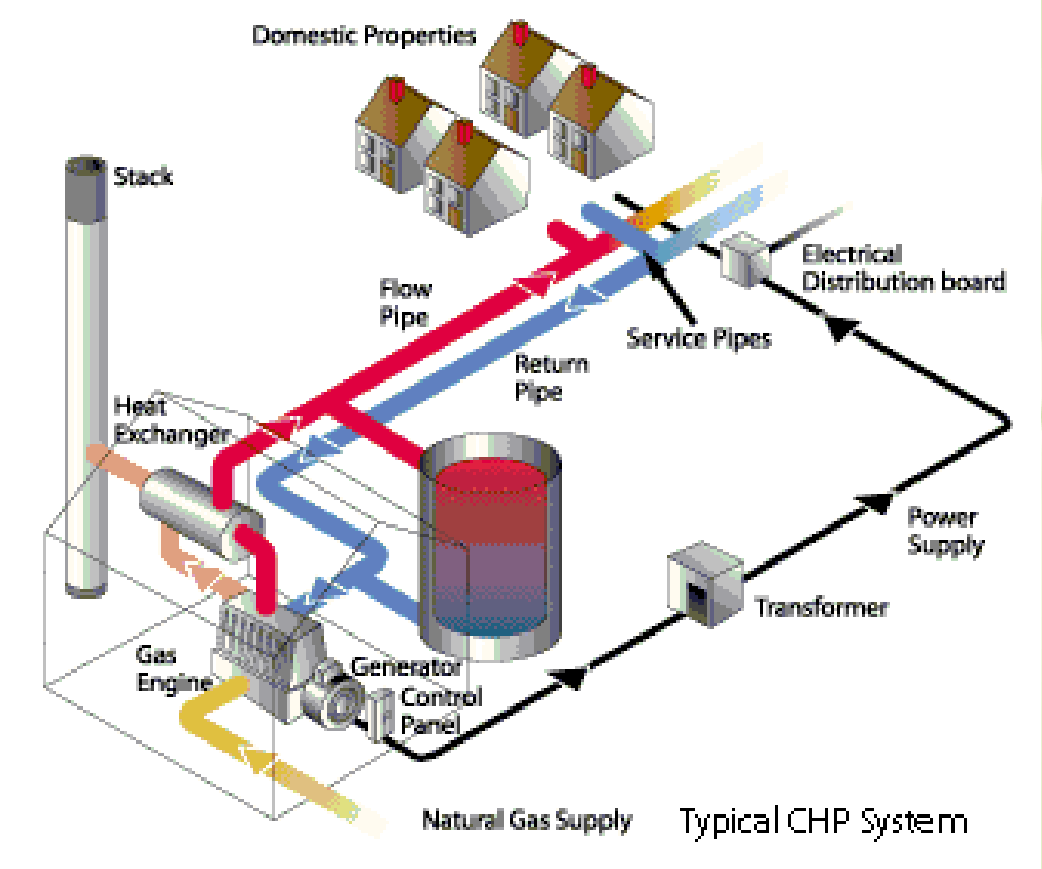
Distribution – centralised, with grid operators



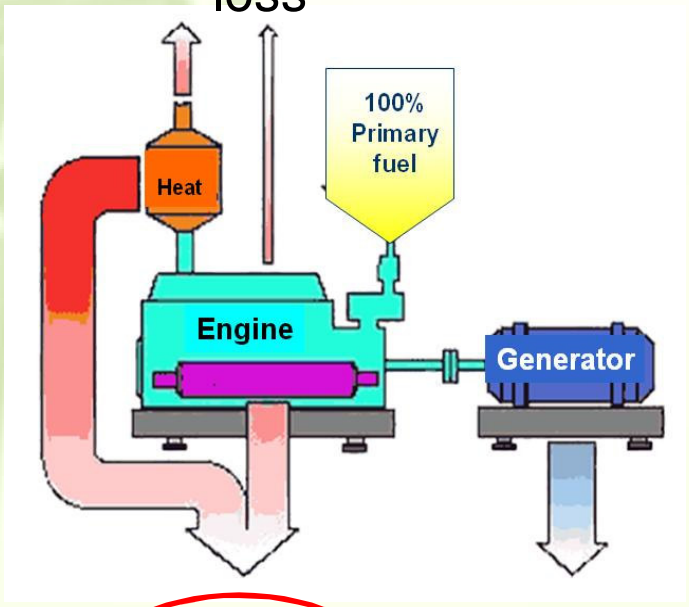
Coal-fired power station
~ 30-35% efficiency

10% losses in transmission

Power distribution - decentralised



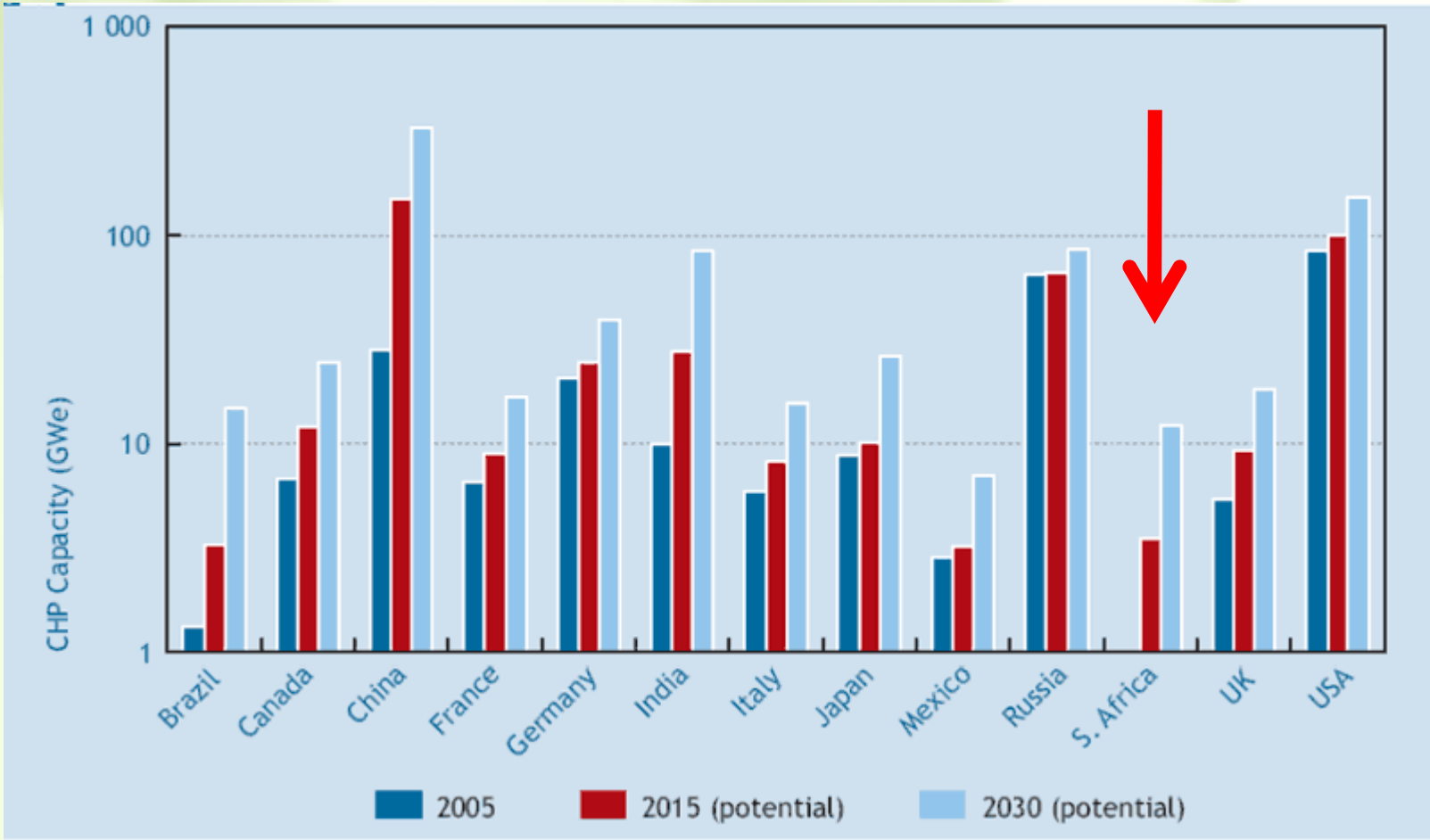
15% flue 5% radiation loss



50% heat

37- 48% electricity

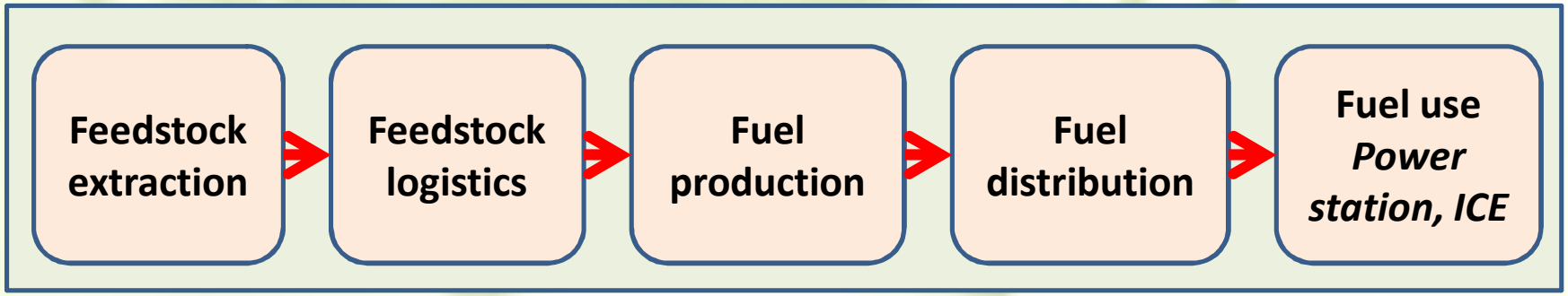
CHP potential



Source: IEA, CHP: Evaluating the Benefits of Greater Global Investment (2008).

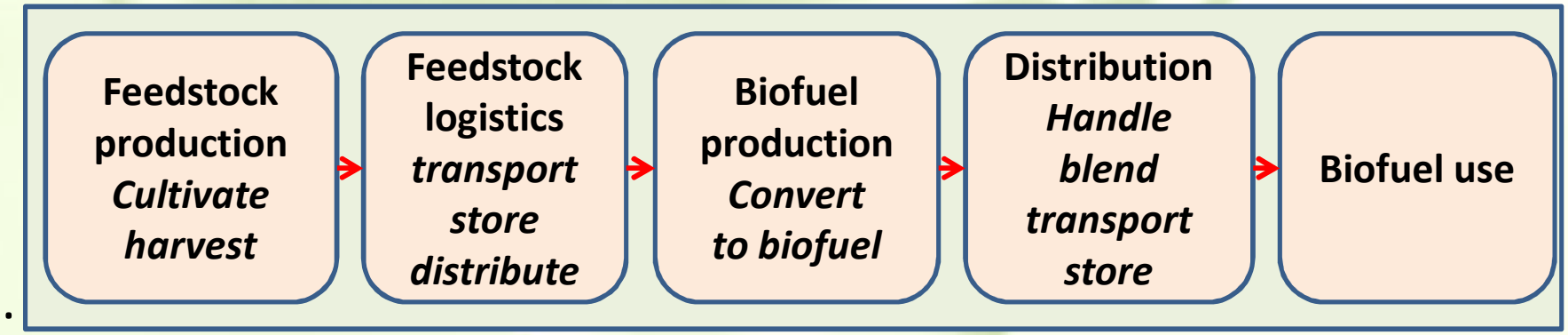
Fossil fuel supply chain

- Well-established



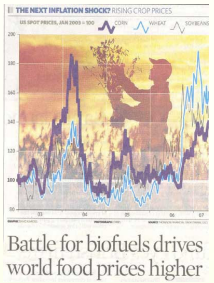
- Fossil fuel: coal, oil (petroleum), natural gas
- ICE's, power stations built to suit materials
- Centralised grid - economies of scale

Biofuel Supply chain(s)?



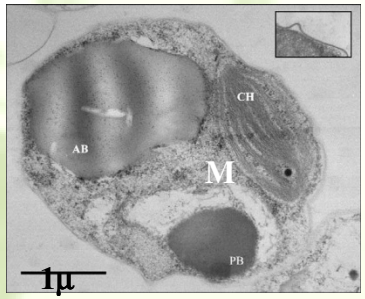
Where are the bottlenecks?
Feedstock

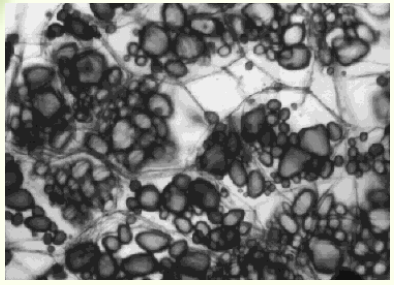
- Feedstock production
  - Agriculture negatives
  - Incentives
  - Microalgae cultivation know-how
- Feedstock distribution
  - 70% water – bulky

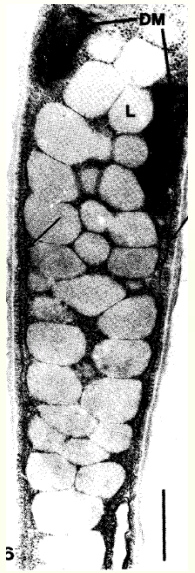


Where are the bottlenecks?
Biofuel production

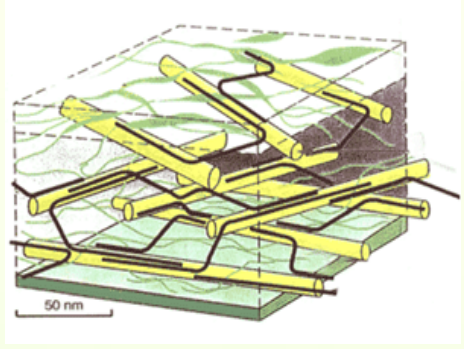
- Biofuel soup
  - Proteins, lipids (oils, fats), polysaccharides, lignin, cellulose





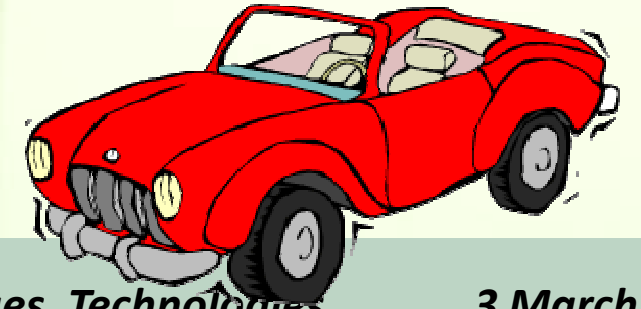


- Technology
  - Lignocellulosics
  - biobutanol



Where are the bottlenecks - what do we (think) we need?

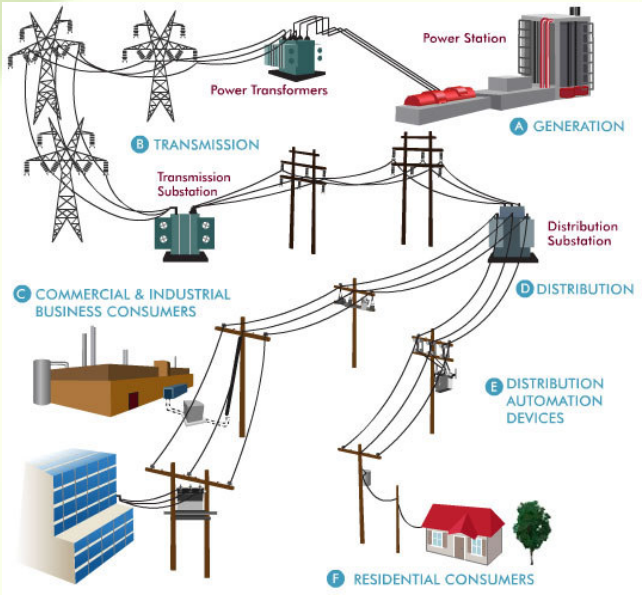
Heating (gas)	45%
Hot water (gas)	16%
lighting (elec)	1%
TV (elec)	0.5%
Cooking (elec)	3%
Dishwasher (elec)	2%
Fridge/freezer (elec)	2%
Washer/drier (elec)	0.5%
Car (petrol)	30%



Source: New Scientist Sept 2006

Integration of biofuels into existing supply chain?

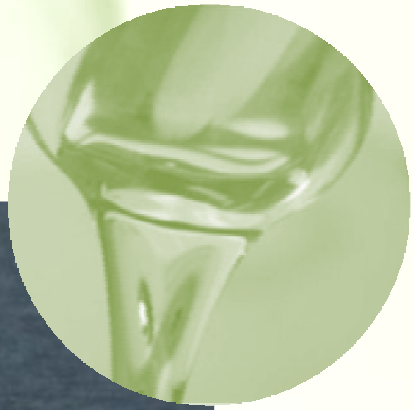
- Biodiesel - engine mods
- Bioethanol – engine mods
- Biogas



- Power Cable Distribution
  - Decentralised or centralised?
  - Consumer installations?
- Operation, service, maintenance of the entire scheme

Glycerol from microalgae

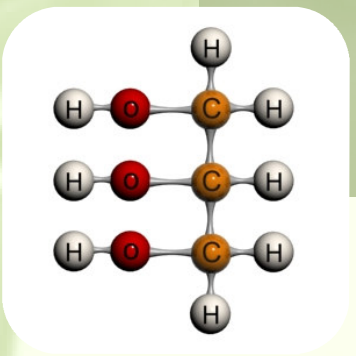
Scenario 2



Marine Auxiliary Engines
Glycerol as a Biofuel

Why glycerol?

- Water-soluble
- Biodegradable, non-toxic
- Non-flammable
- Non-volatile
- High boiling point
- Carbon (CO_2) neutral from biodiesel production



Plant Oil + alcohol → Fatty acid esters + glycerol
(biodiesel)

Will it combust in CHP?

- 2010 - New combustion method

McNeil Combustion Cycle
Standard diesel engines burn liquid/gaseous fuels of
any cetane number without additives/chemical processing

Patent no GB2460996B *Int. Application No.: PCT/EP2009/053274*

Glycerol combustion

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

Emissions	Amount
Particulate	Below detection limits
NOx	0.1g/kWh (3000 rpm engine speed)
SOx	negligible

Marine auxiliary power generation

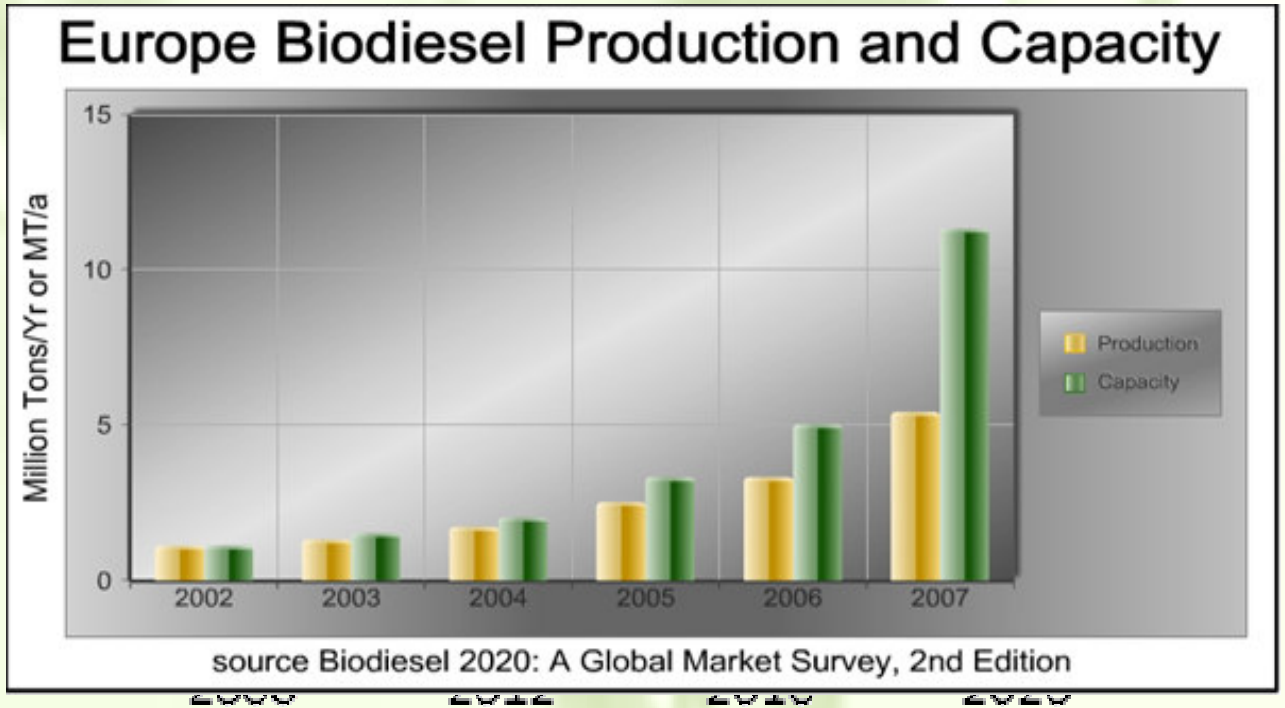
- Comply with ship regulations (SOLAS, SECA, ISO 8127)
- Spills: minimal risk to marine environment
- Mitigate CO_2
  - 0.7 mt glycerol burnt in CHP eliminates ~ 1 mt pa CO_2
- Energy efficient
- Thermal battery
- An existing engine can be used *without* modification to the hardware

Technology Pipeline

- Ship retrofit
  - 1MW CHP engine, ~4800 t glycerol 1y

Glycerol supply?

- European glycerol manufacture from biodiesel



Glycerol supply?



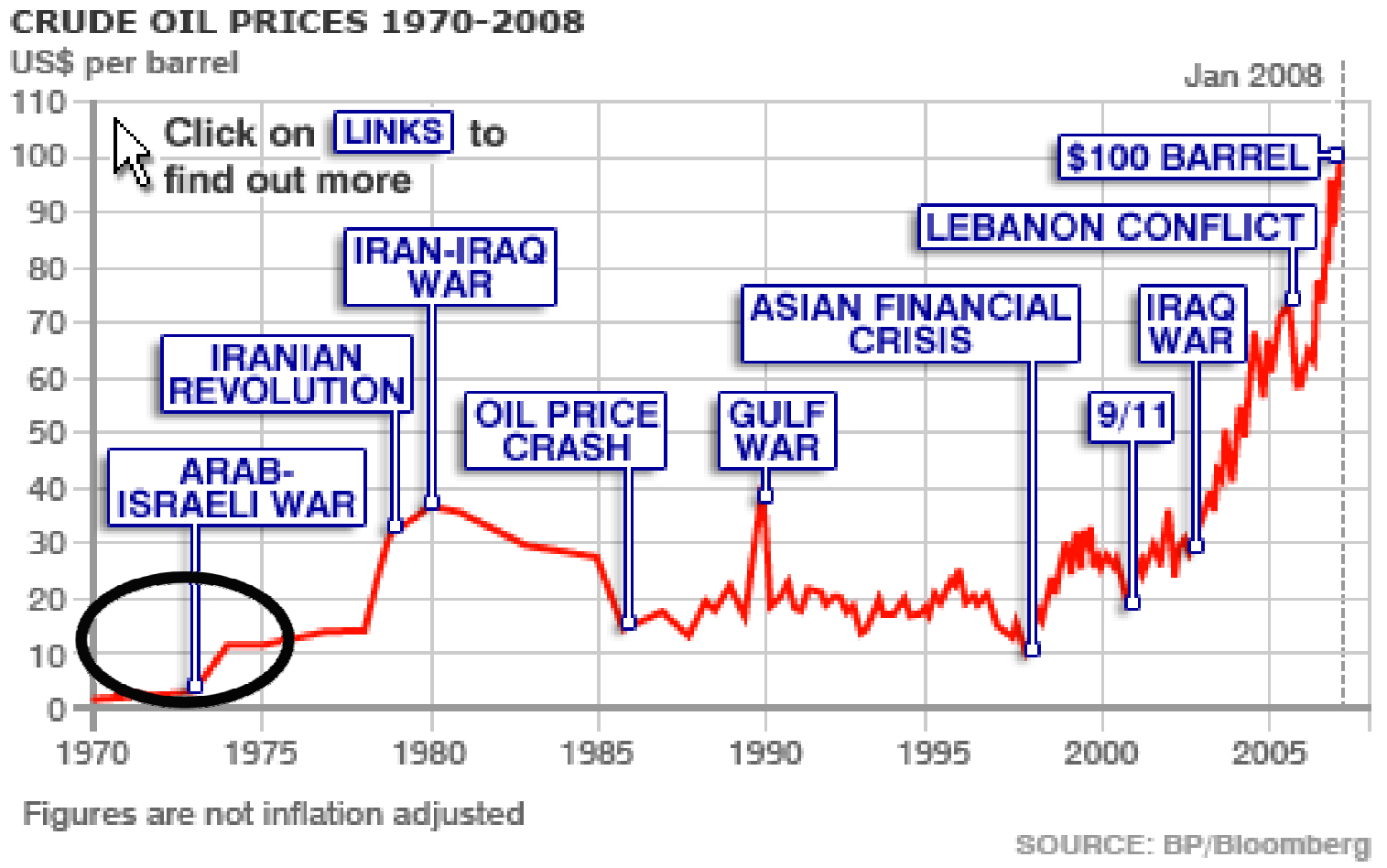



- Africa-Europe Energy Partnership
- Hydrotreated vegetable oil (HVO)
- Alternative markets for glycerol

Glycerol from halotolerant microalgae

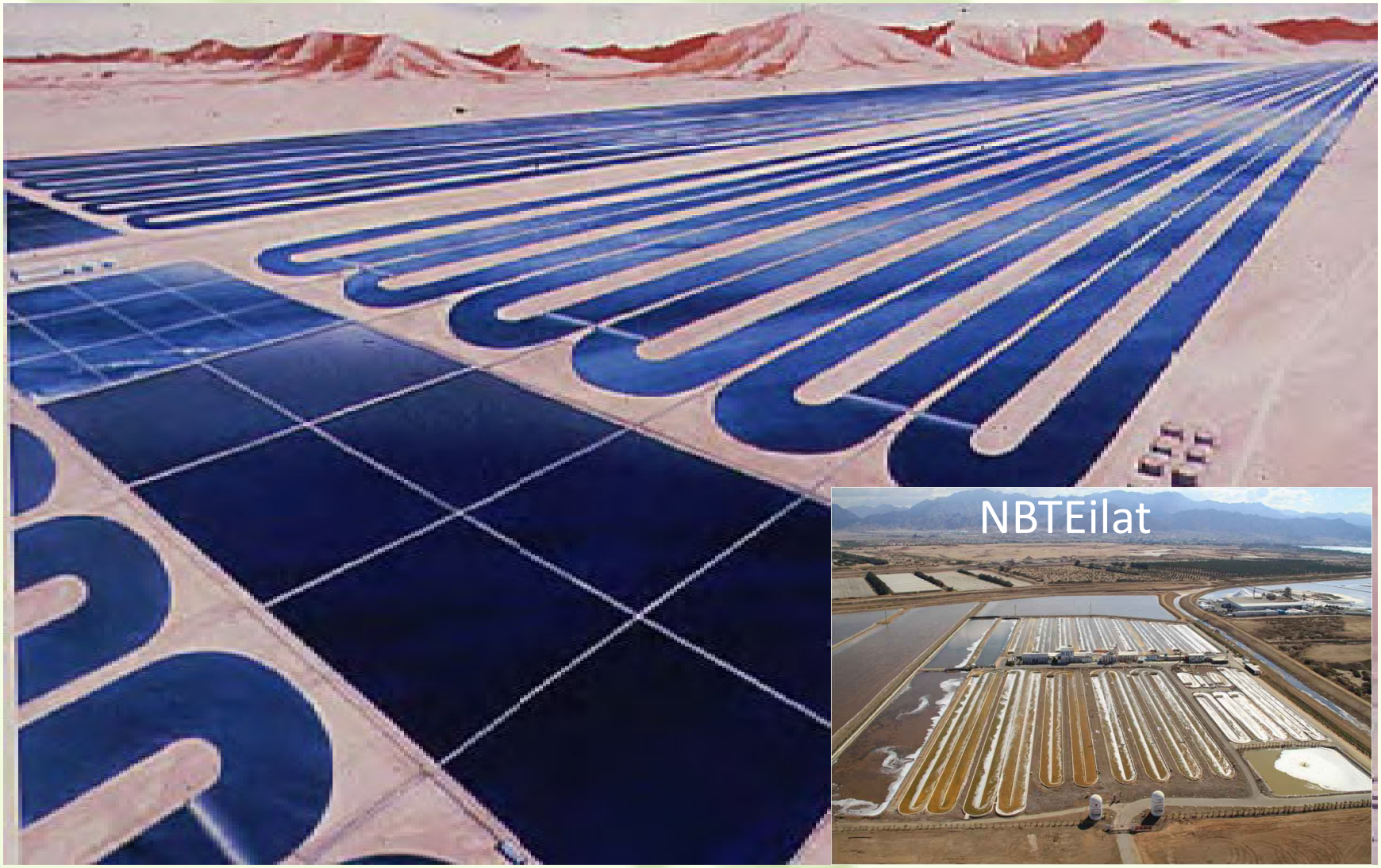
- Osmotic stabilizer
- Halophytes – 4.0M salt
- ~85% biomass (dw) as cytoplasmic glycerol
- Israeli technology: ~40 tons glycerol d^{-1} km^{-2} *–Ami Ben-Amotz*

Oil price / war = ‘must do’

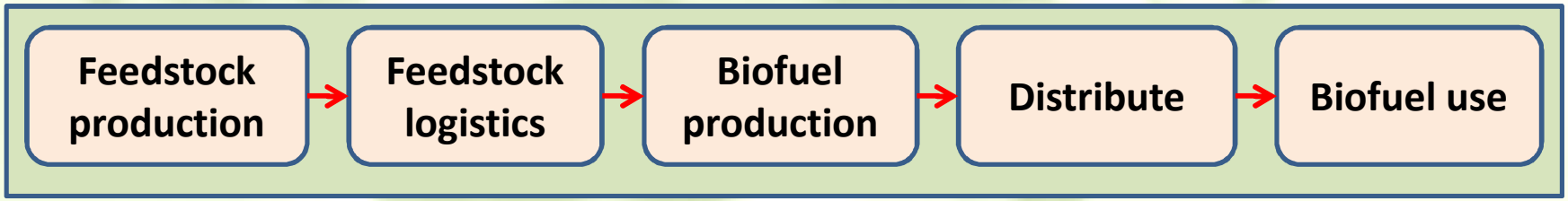


1st Energy Crisis 1975, Glycerol Algal Farm,

500 hectares in Sinai



Glycerol Supply chain?



mindmap