The need to deliver electricity, heat and cooling in Africa can be met with Combined Heat and Power (CHP)

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(John McNeil)

CHP and CCHP - Definitions

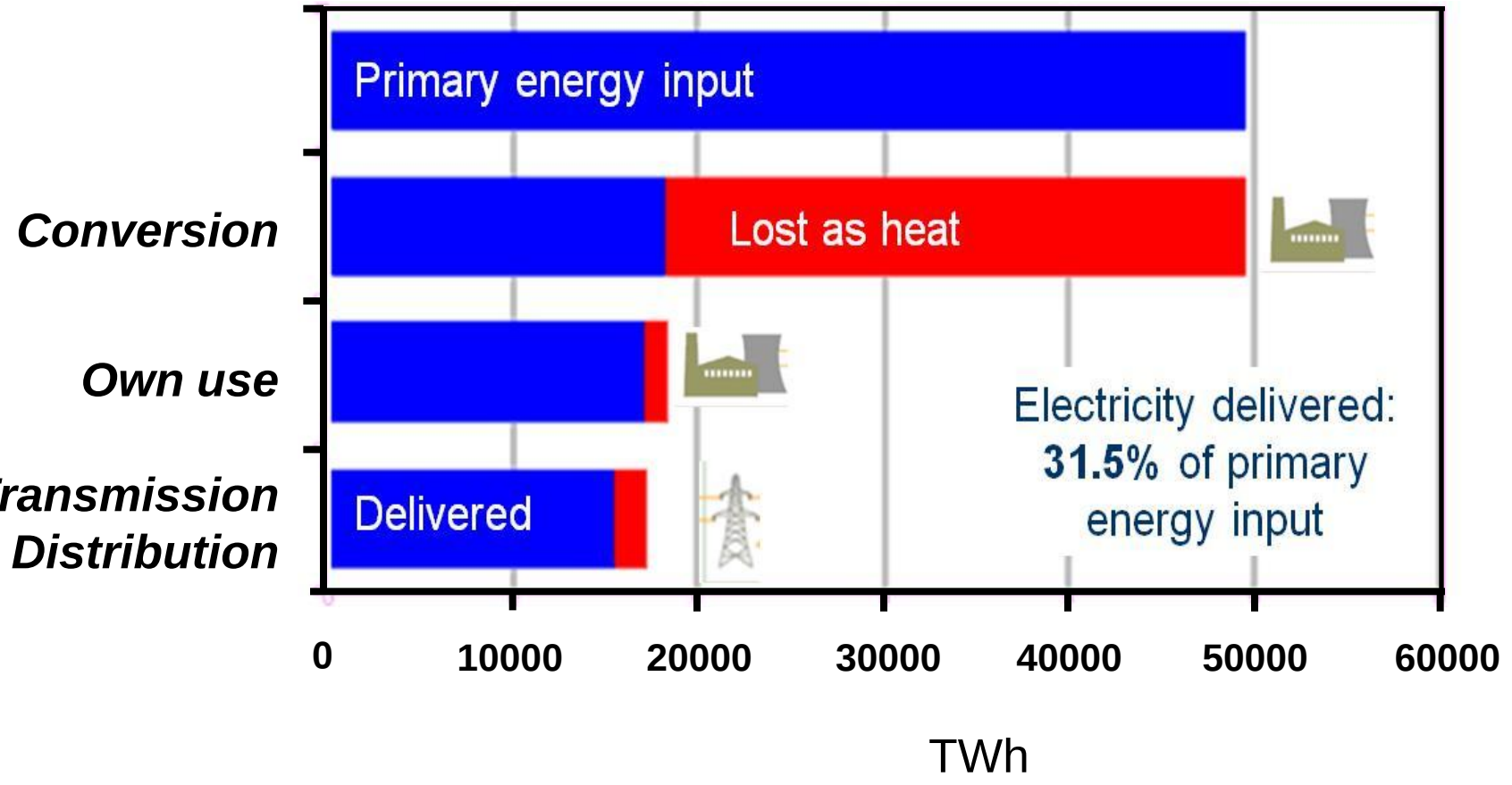
Combined Heat and Power (CHP) or Cogeneration
simultaneous generation of heat and power, usually electricity, in a single process.

Highly fuel-efficient technology that uses the heat – produced as a by-product of energy generation – that would normally be wasted to the environment.

Combined Cooling, Heat and Power (CCHP) or Trigeneration
Highly fuel-efficient technology that uses (some of the) heat to drive an absorption chiller for cooling.

Power station energy conversion efficiency

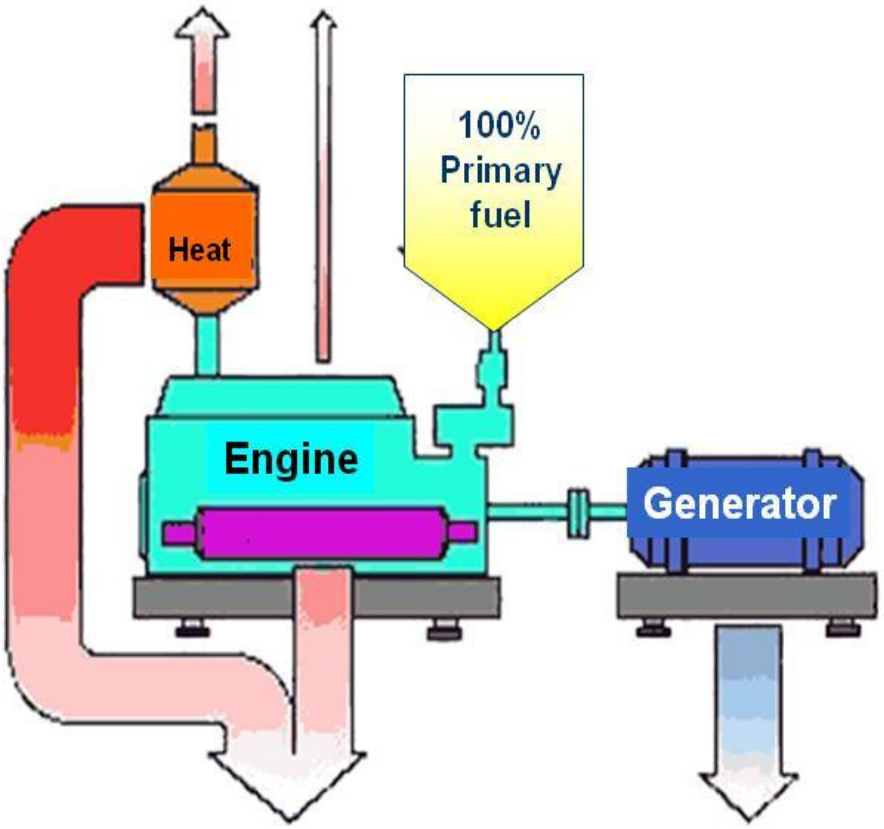
Source: IEA 2008



CHP

Simultaneous generation of heat & power

15% flue loss 5% radiation loss



50% heat 30% electricity

Because CHP supplies electricity locally, transmission and distribution losses are avoided.

The importance of CHP in GHG Emission Reduction Strategy

Group of 8 Summit, Heiligendamm, Germany, July 2007 recommendation:

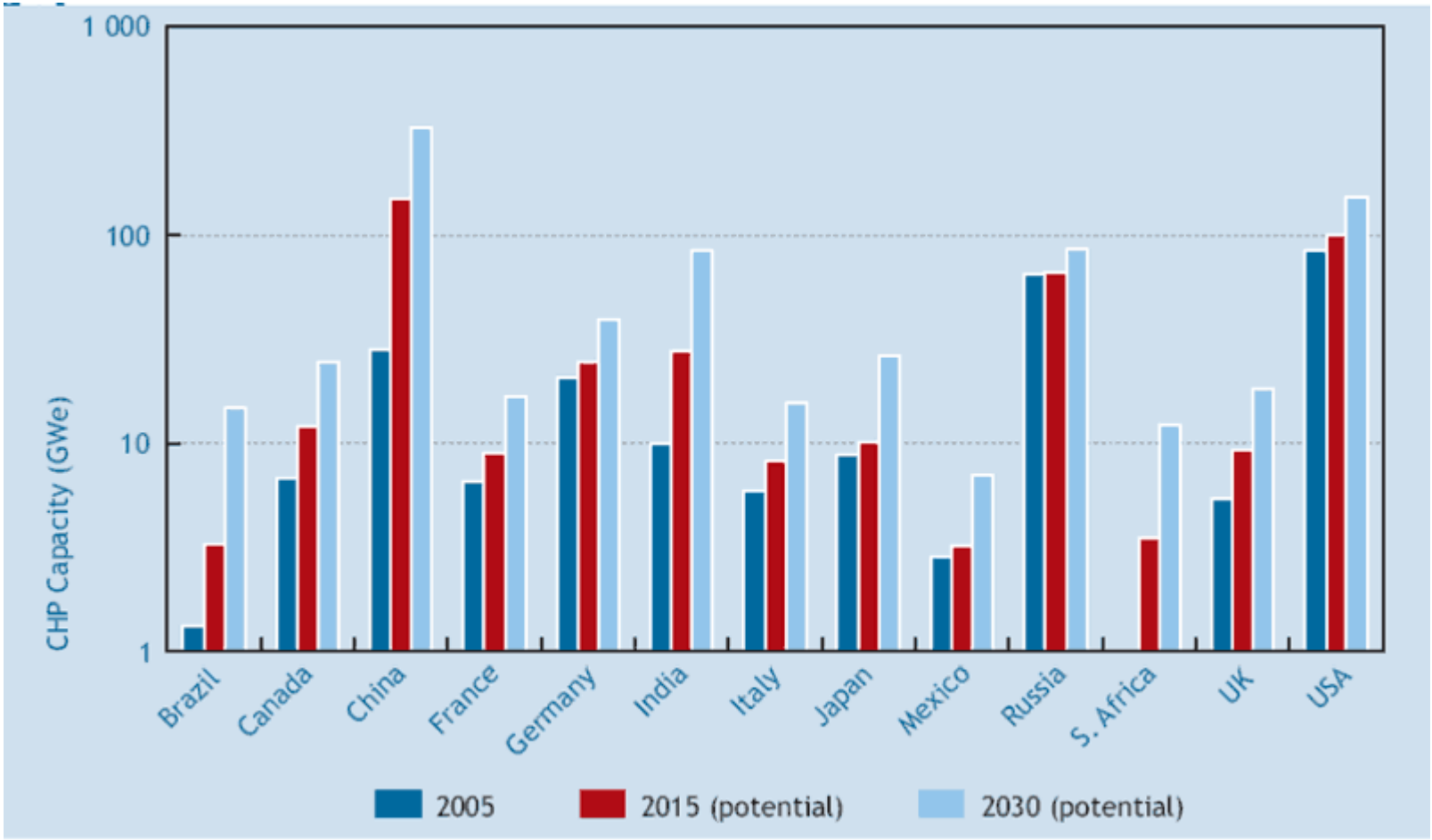
"….adopt instruments and measures to significantly increase the share of combined heat and power (CHP) in the generation of electricity."

International Energy Agency, 2009:

"By 2030, the CHP share of G13 electricity generation could rise from 10% to around 24%

- if suitable policy regimes were to be introduced based on best practice CHP policies."

CHP Potential – G13 Countries



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

In 2010 60% of people in Africa do not have access to electricity

In rural Africa 77% of people are without electricity

	Population without electricity (millions)	*Electrification Rate %*		
		Total	*Urban*	*Rural*
North Africa	2	98.9	99.6	98.2
Sub-Saharan Africa	587	28.5	57.5	11.9
Africa Total	589	40.0	66.8	22.7

Aquafuel

www.**aquafuelresearch**.com

A technology company specialising in:

- Engine driven combined heat and power (CHP)
- Efficient burning of a range of renewable fuels in CHP
- Engine maintenance and lubricant compatibility

Located on the Kent Science Park near Sittingbourne in SE England

www.kentsciencepark.co.uk

Engine types that can be used in CHP

- **Spark ignited engines** (**Otto Cycle)**
  - •Usually uses natural gas or biogas and require high octane fuels.

- **Compression ignition engines (Diesel Cycle)**.
  - •Typically run on Diesel oil, Bio diesel or heavy fuel oil.
  - •Fuels are required to have a high cetane number (measure of ignition) quality.

- **Dual fuel compression ignition engines**
  - •Use a 'pilot' injection of high cetane fuel to ignite a fuel air mixture.
  - •Fuels typically natural gas or biogas.

- **Gas turbines**
  - •Often used for CHP but tend to be very inefficient at low powers.
  - •Are extremely fuel sensitive

Renewable Fuels

- **Oils and fats**
  - Plant oils
  - Animal fats / oils
  - Acid oils
  - Algal oils
  - Pyrolysis and synthesised oils
- **Gases**
  - Bio methane
  - Pyrolysis and synthesis gases
  - Hydrogen
- **Alcohols**
  - Ethanol
  - Methanol
  - Butanol
  - Glycerol

Aquafuel Research Ltd has developed proprietary technology for efficient burning of plant and animal oils and fats and.....

glycerol

CHP or Road Transport?

- Most plant oils and animal fats are presently converted to Bio-diesel (trans-esterification) for the road transport fuel industry.
- This chemical process is costly and carbon intensive.
- Biodiesel is utilised in vehicle Compression Ignition (CI) engines; fuel energy to work conversion efficiency rarely exceeds 25%.
- When compared to efficient CHP use, this equates to ~ 3 times the volume of renewable resource per unit of useful work produced. **!**
- The future of road transport is likely to be a combination of wholly electric or series electric hybrid vehicles. It therefore makes sense to divert the use of oils and fats to CHP.

Oils and fats for CHP

- The work of Aquafuel Research is dedicated to the application of liquid fuels (oils and fats) in CHP.

- Crude plant oils, algal oils and fats can be used in mass produced CI engines for CHP at high electrical efficiency: ~ 34% (10-100 kWe), up to ~ 38% (100-1000 kWe) if processed and used correctly.

- Emissions can be controlled effectively with proprietary equipment provided fuel is correctly processed and correct combustion parameters are maintained.

- Oils and fats tend to have high flash points and low toxicity and can therefore be handled more easily than gases.

- Such fuels have great direct use potential in the local area of production.

Engine problems when using crude oils and fats

- Without correct fuel treatment, fuel injection systems can be irreversibly damaged within minutes leading to loss of injection pressure and damage to injector nozzle needles and seats.

- This in turn leads to incorrect fuel injection spray patterns, injector fuel leakage, increasing emissions, lubricant destruction and finally piston and cylinder liner damage.

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Aquafuel has developed patented fuel preparation and engine maintenance systems to enable the use of most crude oils and fats and mixtures thereof:

- Centrifugal clarification with secondary filtration to clean the fuel
- Process reactor to reduce the corrosive potential
  - pure acid oil fuels can be used.
- Fuel storage and delivery to the engine at a temperature compliant with fuel injector viscosity specifications.
- The 'INCIP' process - the engine runs on a novel, renewable polyol/surfactant mixture for short periods to remove injector nozzle deposits.
- Clean in place cycles linked with simple and cost effective emissions monitoring.
- A renewable, compatible lubricant that meets all required engine standards

10kW CHP unit supplied by Aquafuel Technology Ltd to Sun Biofuels

to run on Jatropha oil in Tanzania

Aquafuel 1.5 MW CHP installation in a tallow plant in Northern Ireland

Aquafuel™

renewable power specialists

Aquafuel has a patented process for the combustion of glycerol in CI engines that uses the novel 'McNeil Combustion Cycle'.....

.....the McNeil Cycle enables standard engines to burn liquid and gaseous fuels of any cetane or octane number without additives or chemical processing.

John McNeil's Invention

"In broad terms the invention involves heating combustion air or working fluid to a temperature which enables and/or optimises combustion of fuels outside the balance of properties and conditions of fuel and combustion conventionally known in the art.

The invention enables the combustion of very low Cetane Number (CN) materials in compression ignition engines, which materials have not hitherto been regarded as compression ignition engine fuels."

Pub. No.: WO/2009/115589 Int. Application No.: PCT/EP2009/053274

Advantages of glycerol as a fuel in used in standard CHP engines

- **Very high efficiency (electrical power)**
  - Higher than any available bio, fossil or synthetic fuel:
  - Small engines (10 – 50 kWe) up to 37%
  - Intermediate sets (100-1000 kWe) up to 42%
  - Very large engines (1000 – 10,000 kWe) up to 48%

- **Very low emissions**
  - High catalyst efficiency (simple exhaust gas composition)
  - Emissions to 1/10 of the proposed Californian 2015 standard
  - No detectable combustion particulate

- **Superior handling properties**
  - Water soluble and totally bio-degradable
  - Non-hazardous - non-flammable; non-toxic
  - Non-volatile (can be stored at elevated temperature)

Glycerol – potential to be the most favoured fuel for CHP

- Glycerol is a pure compound not a chemical mixture making specification simple
- Cleanest of all fuels?
- Safety in use makes it very attractive
- Significant interest from the shipping industry

- A by-product of the biodiesel industry – current supply chain
- Potential to obtain renewable glycerol from algae
- A project to investigate glycerol from algae in Africa is now underway with ACP Partners

Conclusions

- CHP is widely recognised as a key element in the global strategy mix to reduce GHG emissions.
- CHP offers the means to provide power to remote communities in Africa in a scenario where the numbers of people without electricity is growing.
- Plant and animal oils and fats can be burned efficiently in CHP engines without the need for chemical modification.
- The use of renewable oils and fats in road transport is not the best strategy environmentally.
- Breakthrough technology developed by Aquafuel Research has enabled low/zero CN fuels to be burned in CHP engines, notably glycerol.
- Glycerol is arguably the cleanest and safest fuel yet to be used in an engine.
- Renewable glycerol is a by-product of biodiesel manufacture
- In the future, large scale production of renewable glycerol from algae is the way forward.

If you would like to know more

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