MECS
Modern Energy Cooking Services

Emerging fuel options for clean cooking

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ESMAP Energy Sector Management Assistance Program

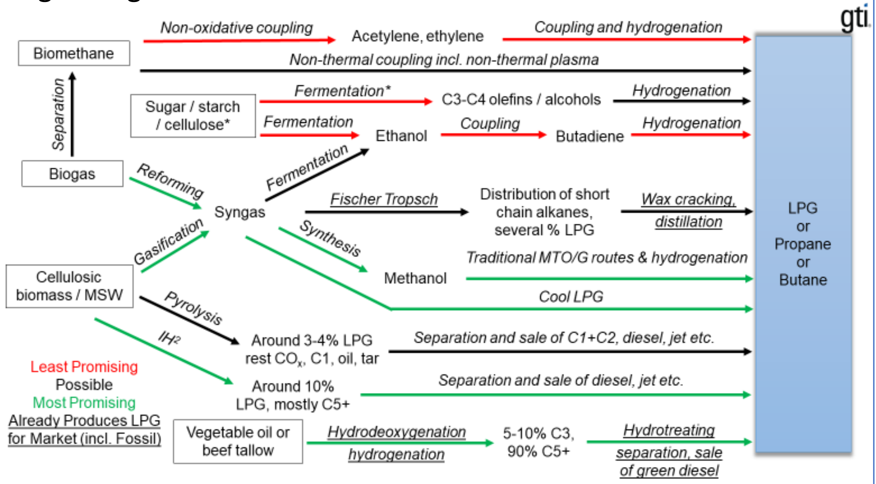
UKaid from the British people

BioLPG (Liquefied Petroleum Gas)

Sources of energy

Fossil LPG production mainly a by-product of primary oil and gas production or of oil refining

BioLPG is produced by chemical conversion of ‘feed gas’ originating from renewable resources



Conversions for cooking

LPG comprises any mix of propane and butane; bioLPG is molecularly identical to fossil LPG

Store bioLPG at moderate pressure, when it liquefies

Use large or small cylinders: identical cylinders as for normal (fossil) LPG

Valve expands it to a gas for combustion in a burner for cooking

Can use a flow meter on valve to measure use

Opportunities & Challenges

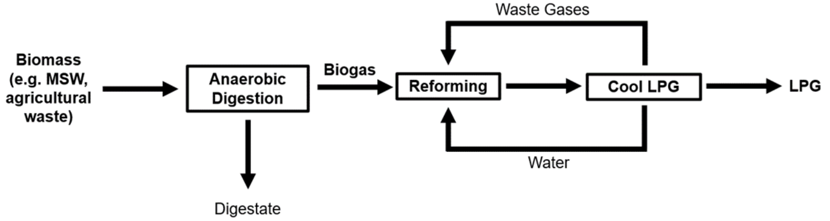
- LPG is an easy-to implement, economically efficient route to rapid scale-up of access to affordable, clean cooking energy
- BioLPG can be dropped into existing LPG distribution and consumer infrastructure and fits immediately into proven policy, regulatory, safety and market best practices
- Climate: LPG derived from fossil fuels has significant climate impact
    - A bio-version would avoid that
    - If feedstocks are sustainably grown biomass, or wastes without other uses, then regard GHG emissions as net-zero
- As for fossil LPG: cleaner burning than solid biomass, but emits nitrogen dioxide, carbon monoxide, and formaldehyde
    - Moves away from gas for cooking in many rich economies, both for climate and for health
- Feedstocks: challenge to find high enough geographic concentrations for cost effective collection, as at present the chemical engineering for conversion works better at large scale
    - Urban MSW looks promising
    - Rural agri-residues more difficult
- Waste management is another major problem: ‘energy from waste’ helps

MECS involvement

MECS funded an initial desktop feasibility study by the Global LPG Partnership: Assessing Potential for BioLPG Production and Use within the Cooking Energy Sector in Africa. GLPGP, September 2020. https://mecs.org.uk/wp-content/uploads/2020/09/GLPGP-Potential-for-BioLPG-Production-and-Use-as-Clean-Cooking-Energy-in-Africa-2020.pdf

Looked at agri-residues and MSW, for Kenya, Ghana & Rwanda, using GTI Energy’s patented ‘CoolLPG’ process

Concluded could be good financial investment case, but depends on feedstocks and local conditions



MECS has funded a follow-up scoping study (preparing for a pre-commercial pilot plant) by the Global LPG Partnership. Focused on defining the framework for analysis for such a pilot plant, with real country-level data

Involves:

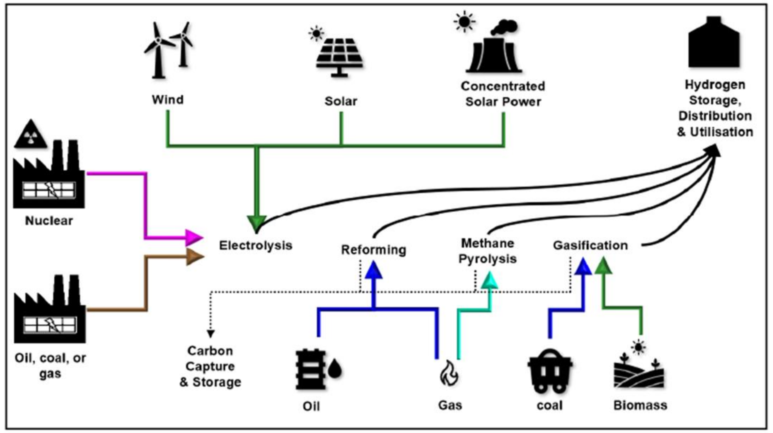
- On-the-ground data gathering on urban MSW feedstocks in Kenya, Rwanda and Cameroon
- Research into the ‘enabling environment’ in each country
- Defining sustainability and financial questions to be answered

HYDROGEN FOR COOKING

Sources of energy

The primary energy source defines environmental credentials; colour used to name, eg Renewables => 'Green Hydrogen' (but all chemically identical)

Energy sources can be large scale or distributed: eg solar PV at grid, minigrid or household scale

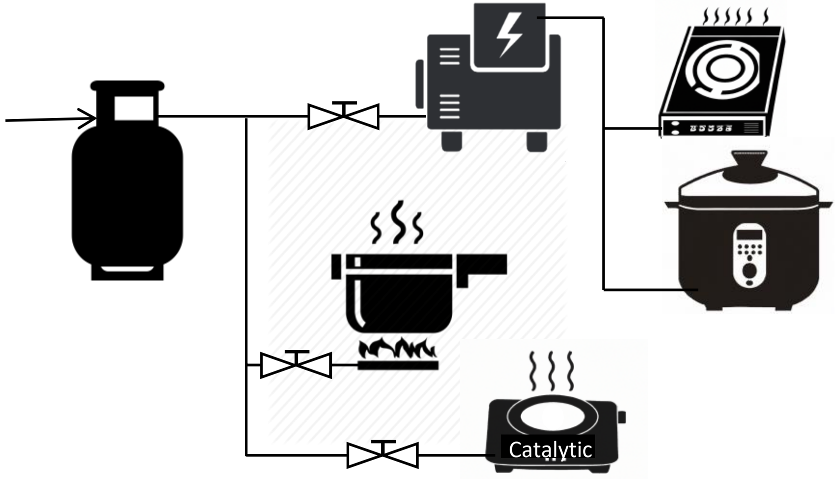


Mukelabai et al., 2022, https://doi.org/10.3390/su142416964

Conversions for cooking

Store H_2 in large or small cylinders

Cook with it as gas (combustion or catalytic heater) or use to generate electracy (and 'waste' heat)

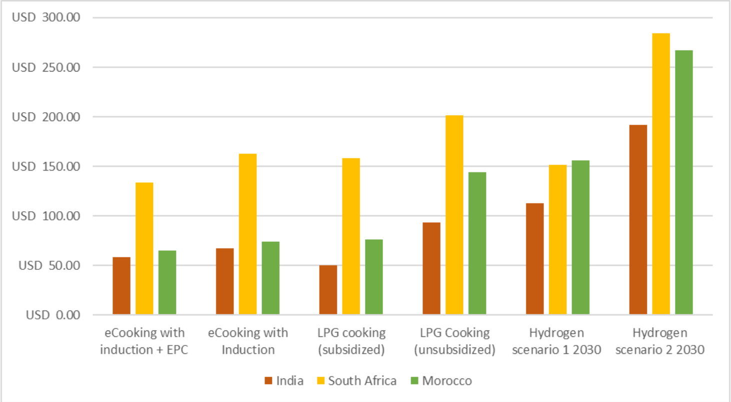


Opportunities & Challenges

- Means to store & transport energy from renewables
  - Adds cost: additional kit for conversions; efficiency losses in conversions; H_2 leakage
  - Electolyser is key component for renewable electricity->green hydrogen. Electricity splits water into H_2 and O_2. O_2 can also be useful.
- H2 can be used for many different energy end-uses
- Whole production system can be localized, or central production + H_2 distribution for local use
- Climate impact: no CO_2 at point of use (but H_2 leakage has some climate effect)
  - can be emissions in production, so use low/zero carbon routes
- Burns quite cleanly: forms Nitrogen Oxides (air pollutant and precursor for particulates and ozone)
  - Minimise emissions through catalytic burner or electricity generation in a fuel cell
- Will need bespoke kit (burners, storage etc), and needs care about safety, so costly at start
- Lot of activity for hydrogen in many sectors, so innovation and scale-effects will drive down costs

MECS involvement

Commissioned consultancy: "Review study on the Hydrogen Transition and Cooking", Matthias Galan, March 2023.
https://mecs.org.uk/wp-content/uploads/2023/03/Report-green-hydrogen-Matthias-Galan-clean-to-publish_MG.pdf



Annual cost of cooking (USD/year). H_2: direct combustion of green hydrogen, lower and higher cost assumptions

Sources & links

Hydrogen for Cooking? A Review of Cooking Technologies, Renewable Hydrogen Systems and Techno-economics
Mukelabai, Mulako, Upul Wijayantha, and Richard Blanchard. 2022. Loughborough University. https://hdl.handle.net/2134/21746921.v1

Environmental sustainability of renewable hydrogen in comparison with conventional cooking fuels.
Ximena C. Schmidt Rivera, Evangelia Topriska, Maria Kolokotroni, Adisa Azapagic. Journal of Cleaner Production 196 (2018) 863-879.
https://doi.org/10.1016/j.jclepro.2018.06.033

Geopolitics of the Energy Transformation: The Hydrogen Factor. IRENA: Abu Dhabi, United Arab Emirates, 2022.
www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen

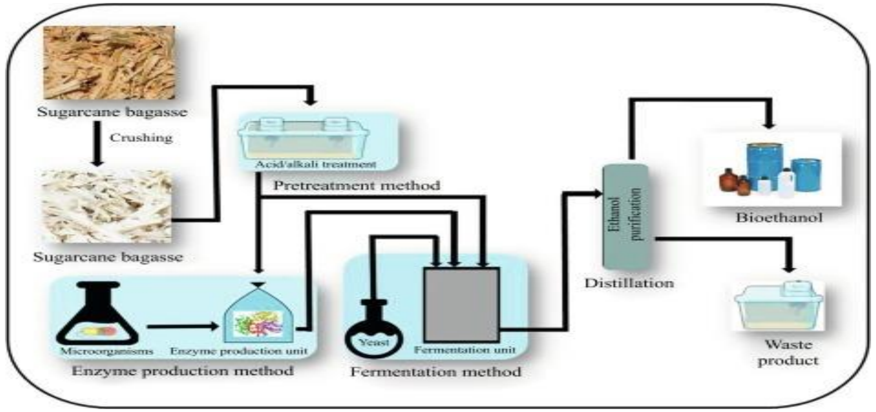
Hydrogen. IEA: Paris, France, 2021. www.iea.org/reports/hydrogen

BIOETHANOL

Sources of energy

Bioethanol is alcohol based in nature, produced by fermentation of sugars & starch from crop wastes/residues or energy crops.

Energy crops include; sugarcane, cassava, potatoes, water hyacinth, grains (wheat, rye, barley, soybeans, maize) and wood.



Tyagi et al., 2019: https://www.sciencedirect.com/science/article/abs/pii/B9780128154076000022

Conversions for cooking

Bioethanol is sold using canisters of different volumes to address affordability.

The burner(s) producers a clean blue flame and has a regulator to control the size of the flames.

Opportunities & Challenges

- Bioethanol for cooking supports 13 out of 17 SDGs (i.e., SDGs Nos; 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, & 15).
- The absence of rigorous analysis of the benefits, historical barriers to scalability, currently limits the understanding of the potential contribution of bioethanol fuels and stove technologies for cooking.
- Burns cleaner with lower GHG emissions and has high energy content when burnt.
- At production level, its considered carbon neutral (same amount of carbon released is absorbed during photosynthesis).
- Bioethanol is renewable energy: its energy is primarily conversion of the sun's energy into usable energy.
- On going debates: food vs fuel, biodiversity, and carbon neutrality.
- Food vs fuel debate: when crop residues/wastes are used as source of energy without other current uses, the debate does not hold.
- Biodiversity debate: requirements for large arable land to grow crops destroying natural habitats & rainforests, the debate does not hold when crop residues are used.
- Carbon neutrality debate: the debate on neutrality of bioethanol in reference to land use of an area may not hold but might be a debate on concerns of bioethanol transportation and the burning of the crop residues.

MECS involvement

- Ongoing literature review on bioethanol for cooking – Contribution to the : Special Issue "Energy Transition and Sustainability in Emerging Economies: Clean Energy and Net Zero Emission : https://www.mdpi.com/journal/energies/special_issues/LY26JA5Q03
- Bioethanol for cooking can be scaled up by addressing several barriers, categorised under 3 dimensions of MECS transition theory of change (TToC) as follows:

$	Consumer demand – related barriers include poverty/affordability, awareness, finance, reliability of fuel supply, consumer preferences and safety.
	Supply Chains - performance of stove technology, startup/business finance required to acquire cook stove technology, support from comprehensive commercial approach .
	Enabling environment – lack of policy support due to unawareness of economic, social and environmental benefits of bioethanol & Inappropriate ear marked government taxes.

Sources & links

Production of Bioethanol From Sugarcane Bagasse: Current Approaches and Perspectives, Swati Tyagi, Kui-Jae Lee, Sikandar I. Mulla, Neelam Garg, Jong-Chan Chae, 2019. https://www.sciencedirect.com/science/article/abs/pii/B9780128154076000022

Unlocking the bioethanol economy: A pathway to inclusive and sustainable industrial development in developing countries. United Nations Industrial Development Organization. UNIDO, 2022. https://www.unido.org/sites/default/files/files/2022-08/UNIDO_Ethanol_Summary_Report_screen.pdf