Pathways to Cleaner Cooking

Stoves 101

a welcome to the sector

&

Gasifiers

Multiple potential paradigm shifts for charcoal production, urban cooking fuels and climate change mitigation&adaptation

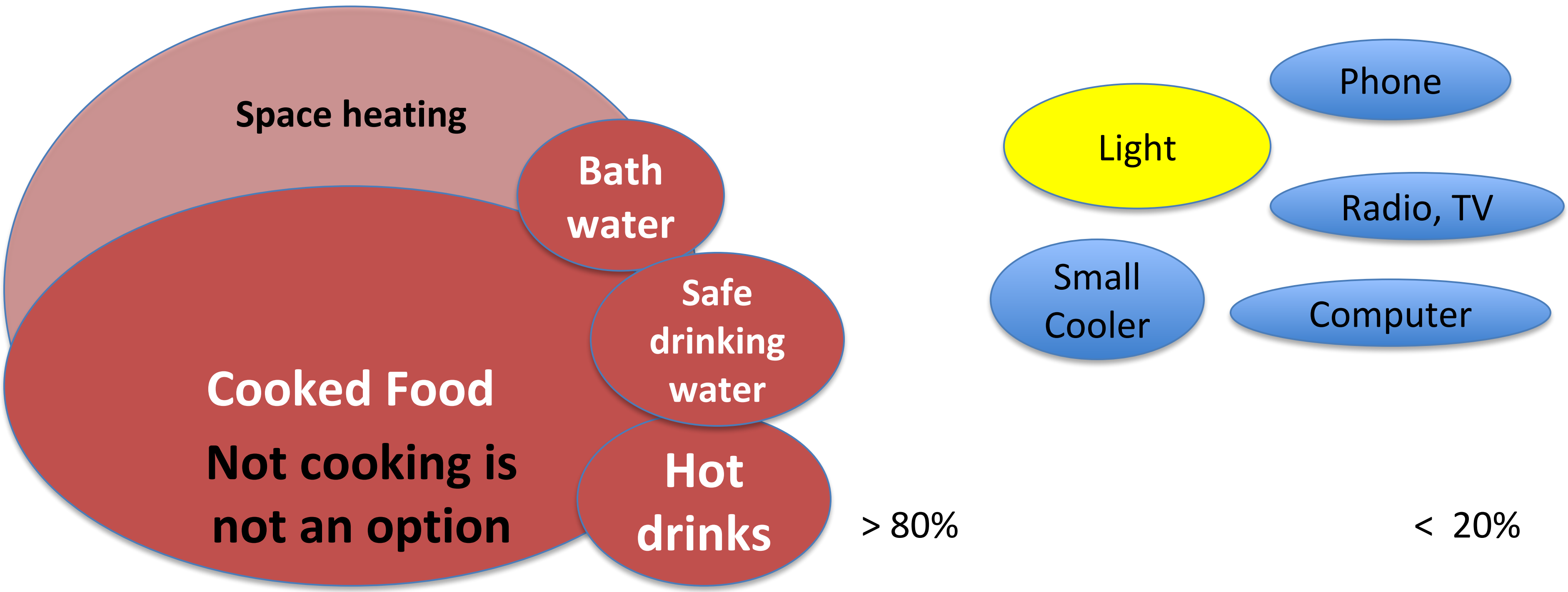
christa-roth@foodandfuel.info

Wexford, 29th May 2019

Relevance of Cooking Energy for Households

Thermal Energy for cooking and heating
= Vital for survival

(Electric) Energy for Lighting, Cooling, Communication, Entertainment
= Quality of Life

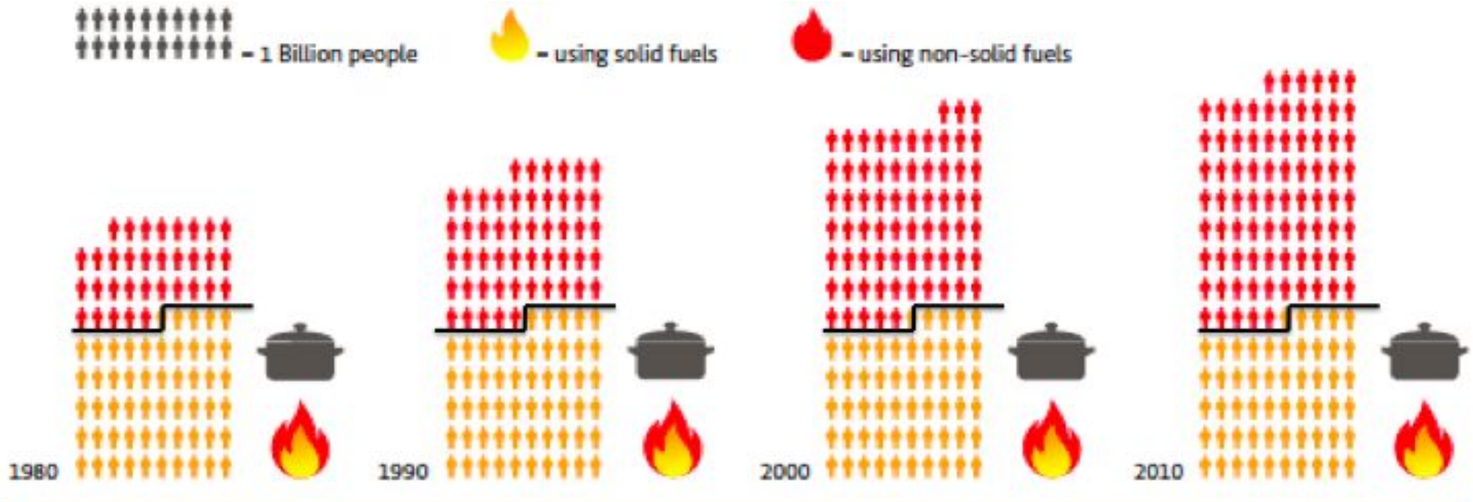


Orders of magnitude of typical energy requirements:

Heating stove	5,000-10,000 W	Laptop Computer	50-100 W
One hot-plate for cooking	500-1,000 W	LED bulb (150 lm/W)	0.5-1 W

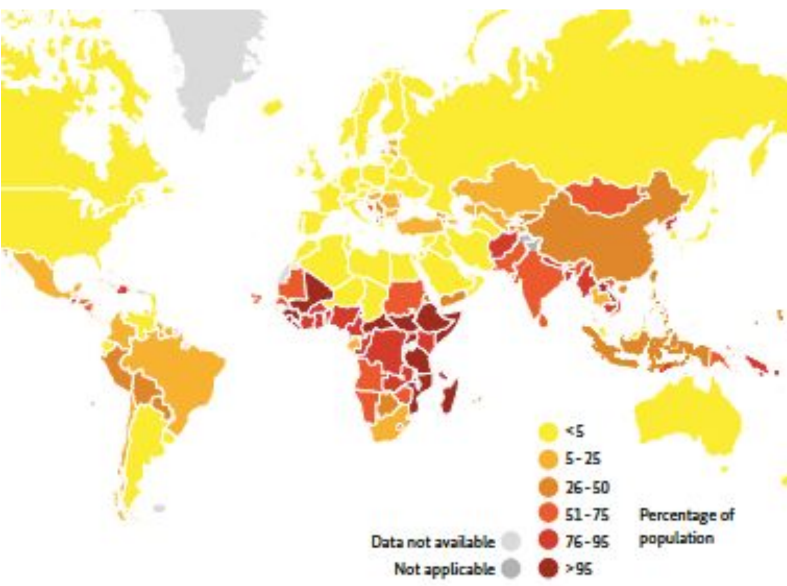
People will still be cooking with solid fuels in 2050

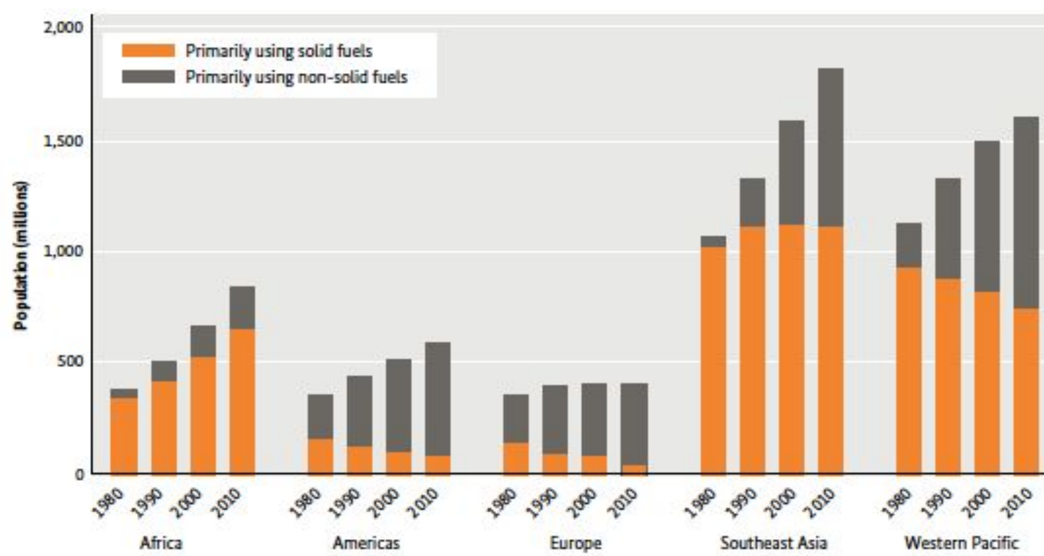
in Africa numbers are likely to increase, while in Asia numbers are stagnating /decreasing

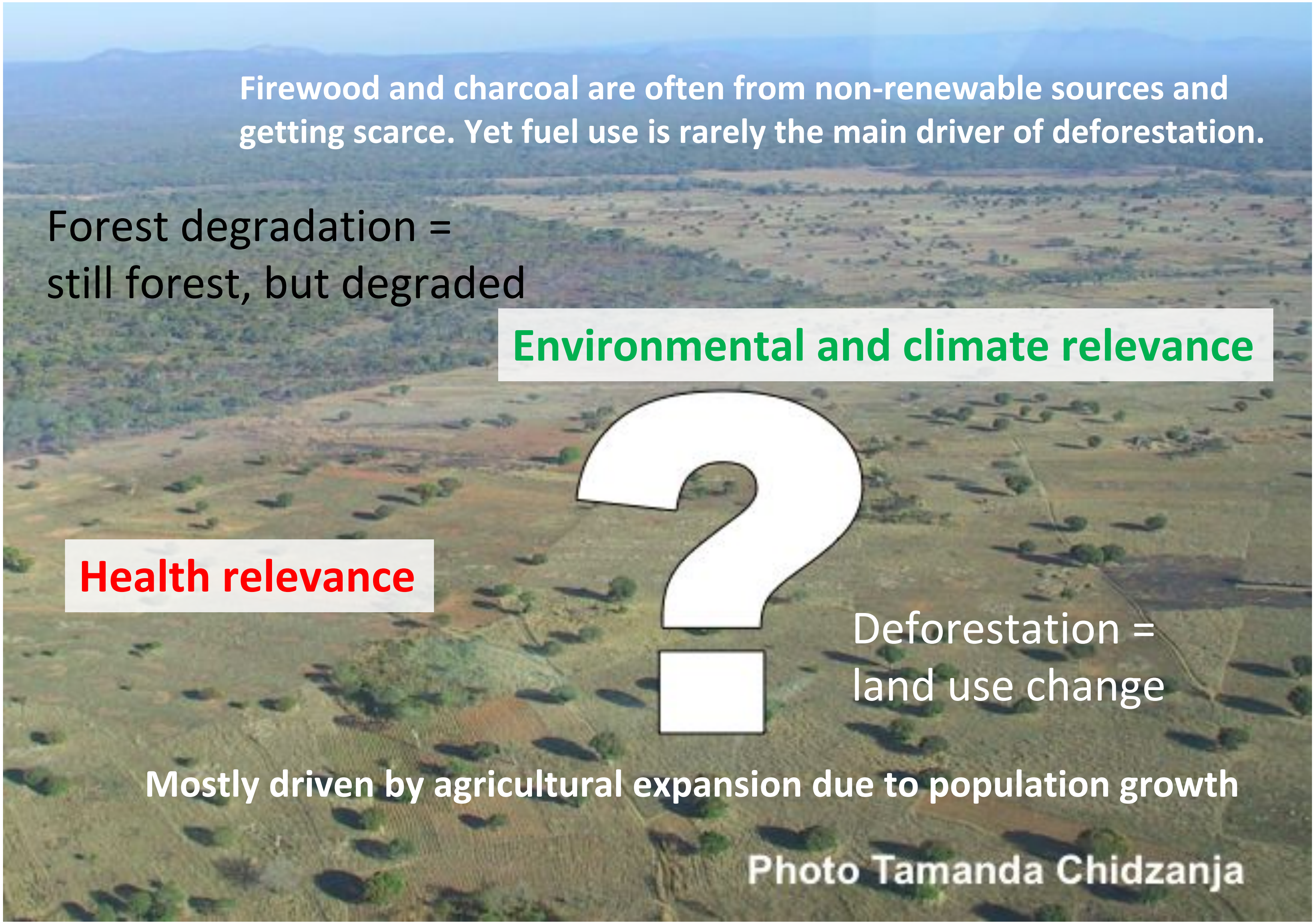


No change in
Solid fuel users
over 30 years

Source: Adapted from WHO and Bonjour et al. (2013)





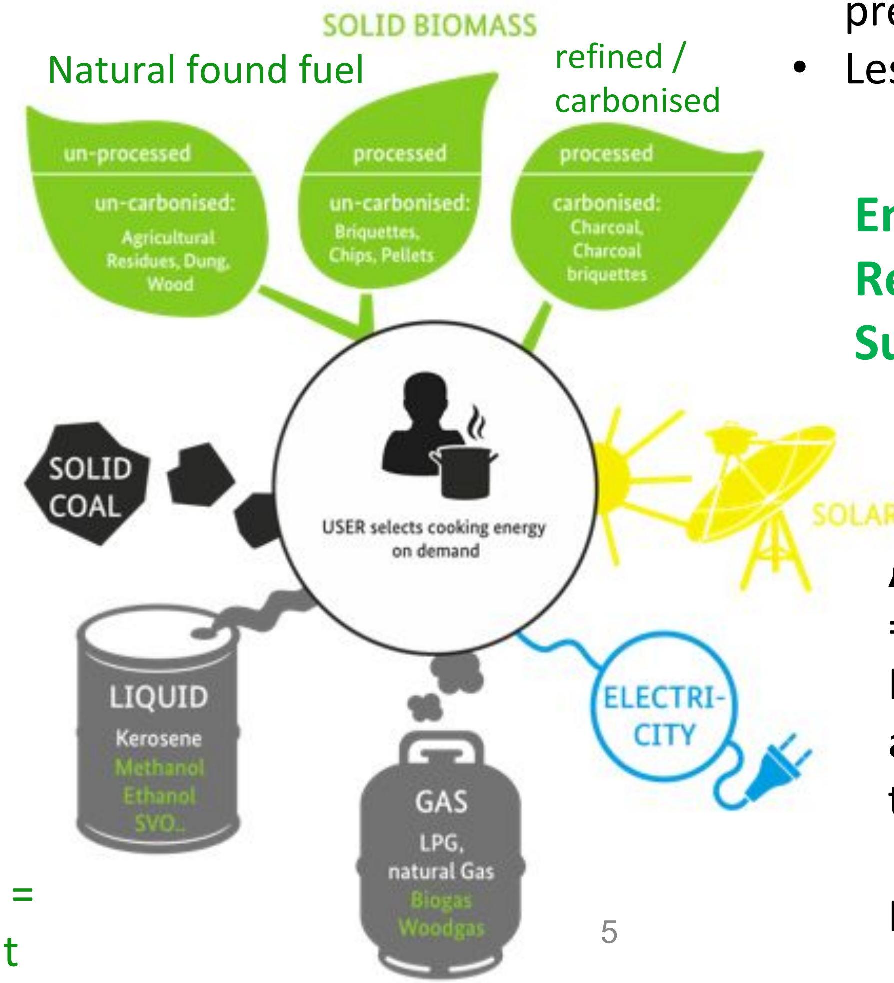

Firewood and charcoal are often from non-renewable sources and getting scarce. Yet fuel use is rarely the main driver of deforestation.
Forest degradation = still forest, but degraded
Environmental and climate relevance
?
Health relevance
Deforestation = land use change
Mostly driven by agricultural expansion due to population growth
Photo Tamanda Chidzanja

Human Health-focused Pathways to Cleaner Cooking: Make the clean available and the available clean

Increase access to ‚clean fuels‘

- Biogas
- LPG
- Electricity
- Ethanol
- Natural Gas

Stove design starts with the fuel



Legend:
Renewable fuel = Climate relevant

‚cleaner‘ cooking

with available solid biomass fuels

- Improved combustion by better fuel preparation and appropriate stoves
- Less exposure by better ventilation

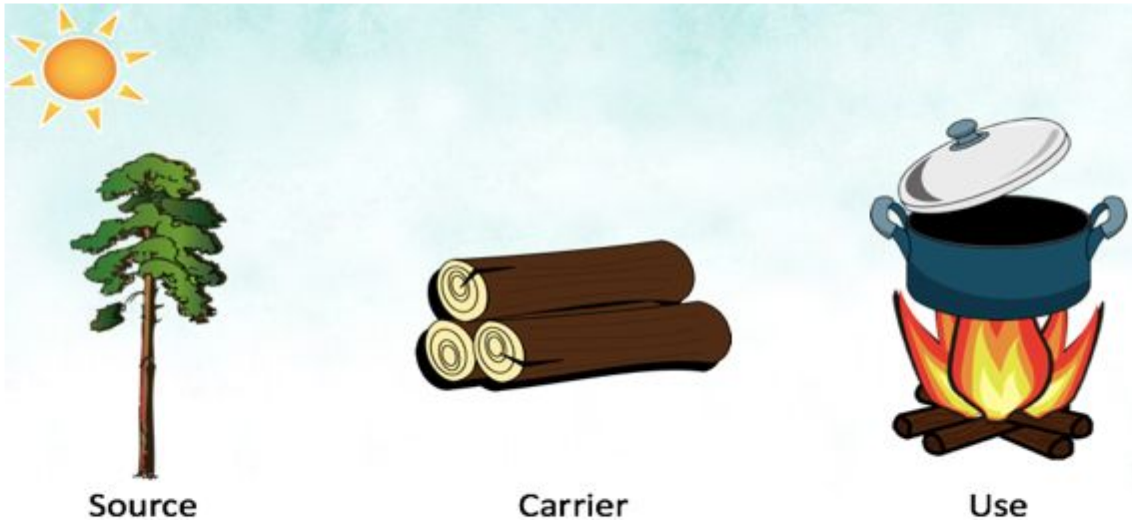
Environmental&climate focus:
Renewable fuels
Sustainable biomass production

‚Energy shelf‘

= User decides for ‚Stacking‘: Parallel usage of multiple fuels and devices depending on the task and availability of fuel

Fuel stacking = Stove stacking

Energy from solid biomass

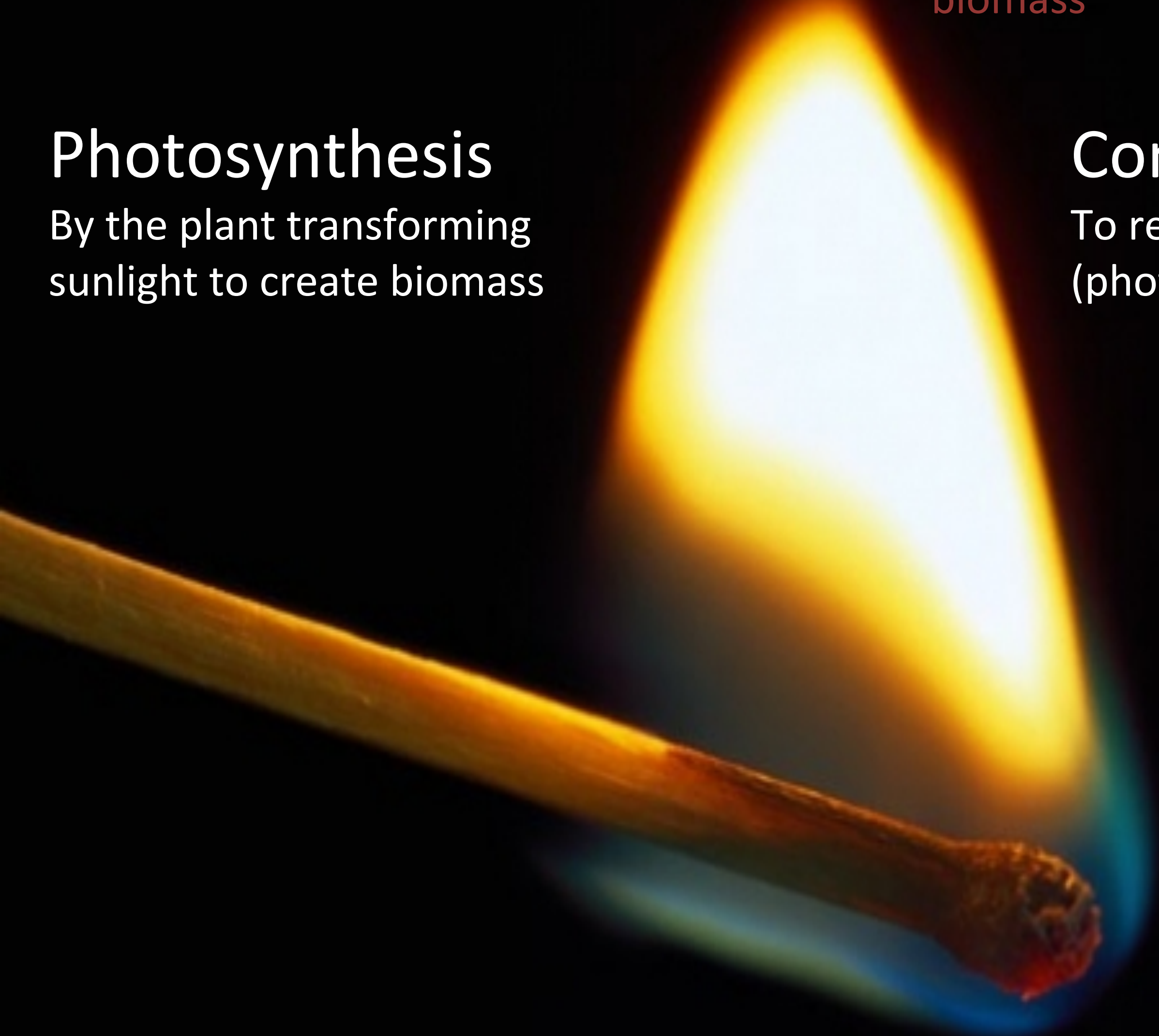


Graph by Dan Sweeney

- **Solar energy** stored by a plant through photosynthesis
- Renewable & climate neutral (with sustainable management)
- Available on demand (unlike other energy sources)
- Safe and easy to store, no disposal issues (unlike batteries)
- High calorific value (1kg=0.4kg LPG or 0.7kg ethanol, ideal source of thermal energy for any food preparation, drying, heating or productive use)

$6\,CO_2 + 6\,H_2O$ + energy = $6\,O_2$ + $C_6H_{12}O_6$ = $6\,CO_2 + 6\,H_2O$ + energy

sunlight — biomass — LIGHT+ HEAT



Photosynthesis

By the plant transforming sunlight to create biomass

Combustion of biomass

To release the stored solar energy (photosynthesis reversed)

Products of Complete Combustion=

CO_2

H_2O

HEAT

LIGHT

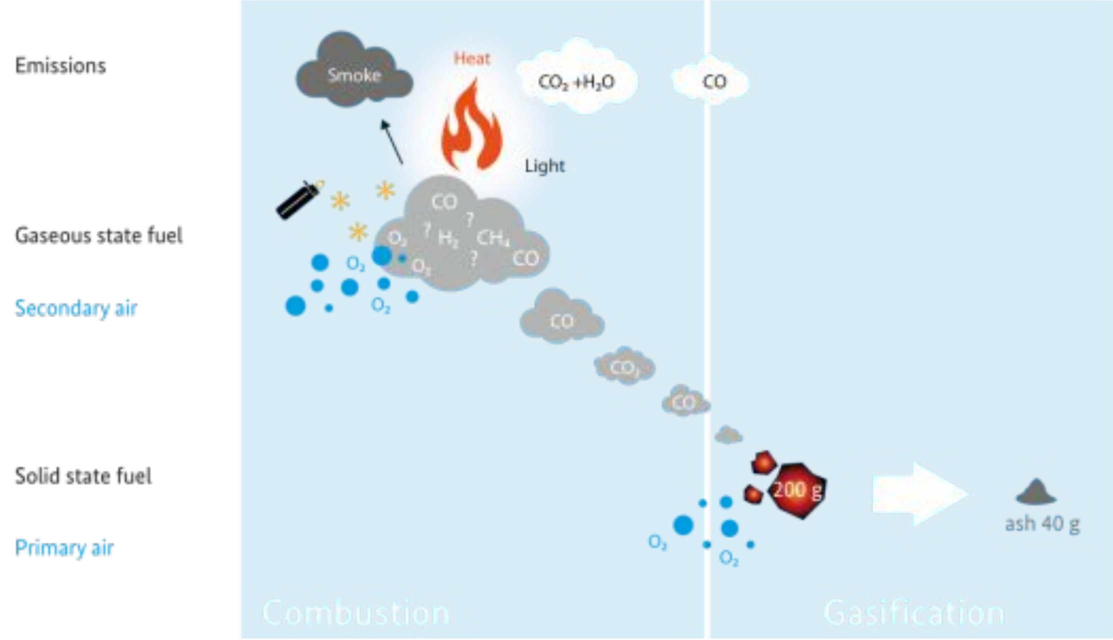
(+ash)

Note: CO_2 is a natural ingredient of ambient air, not a risk for human health, but for climate.

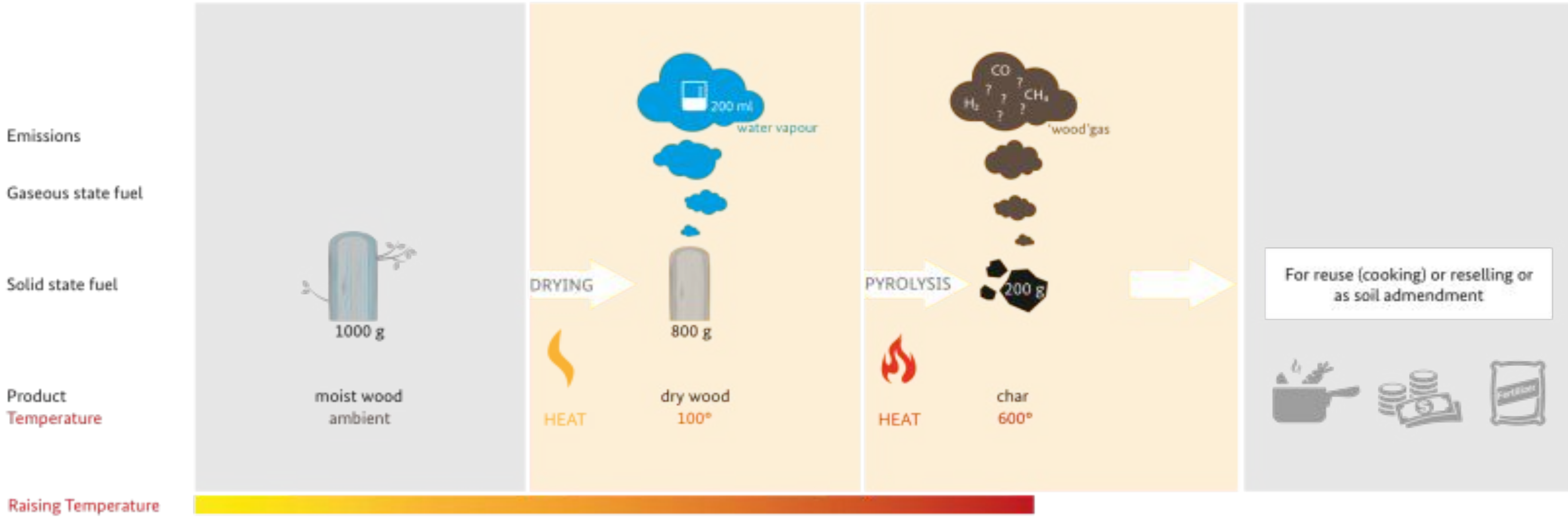
Understanding fire

to optimise useful heat output & limit harmful emissions

How does biomass burn: Stages of biomass combustion

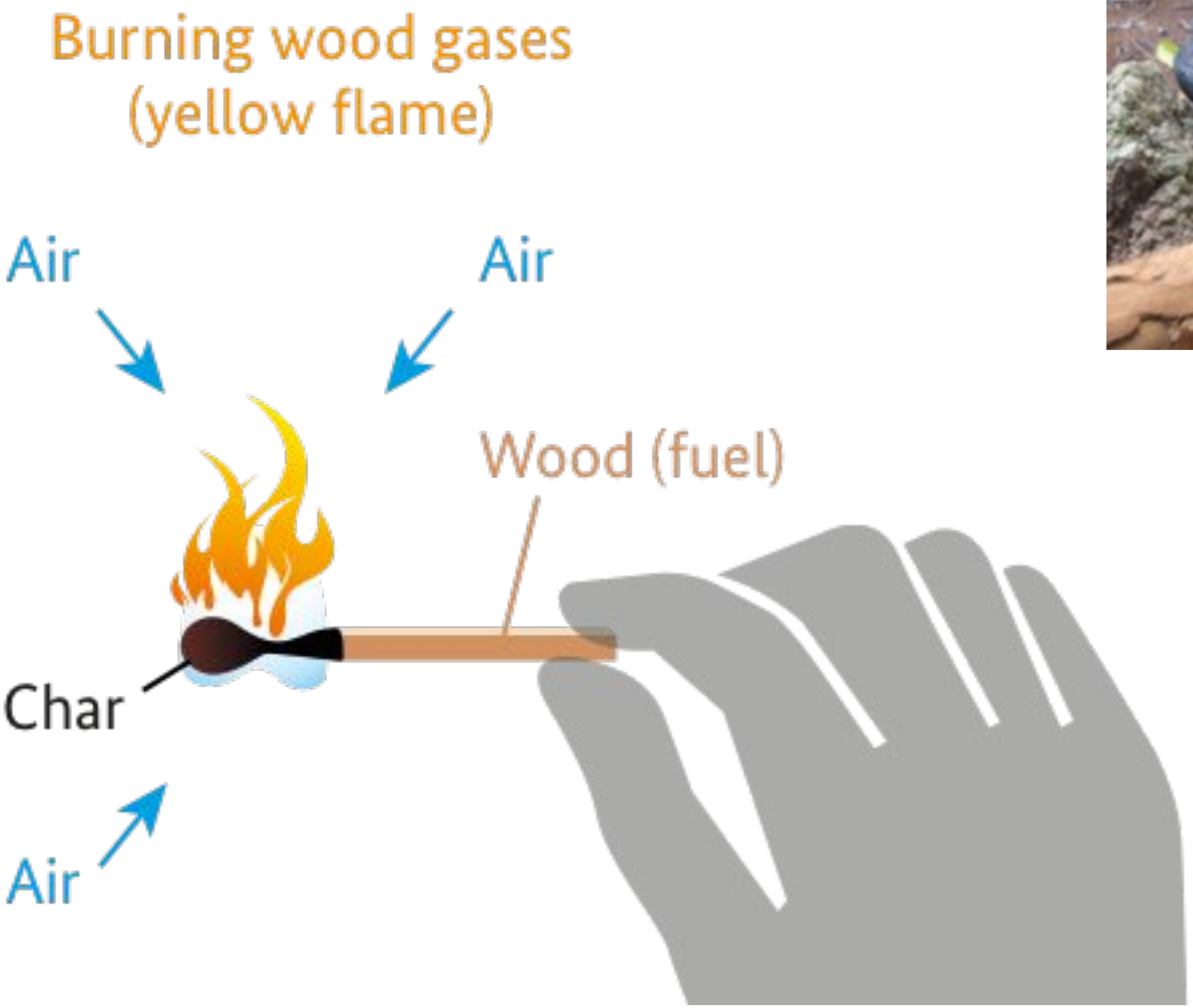


2 : Gas Combustion (controlled by **AIR**)



1 : Gas Generation (controlled by **HEAT**)

Where is the best spot for a cook-pot?



What is a ‚Stove' =

Heat-Generator

= How to make most heat from a fuel

Factors to optimise complete combustion:
„the 3 T's of combustion"

Time, **T**emperature, **T**urbulence

Fuel Specific re size, shape, moisture content and state of carbonisation:

- Uncarbonised
    - ‚stick'-wood, twigs
    - Briquettes
    - Woodchips, nutshells, pellets
- Charcoal lumps, carbonised briquettes

Heat-Transfer-structure

= How to get most heat into the pot

Factors to optimise heat transfer:
‚TARP V'

Temperature, **A**rea, **R**adiation, **P**roximity, **V**elocity

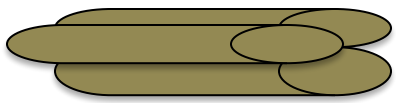
‚Form follows function':
depending on

- Fuel
- Cultural and human factors
- meal type, type of cooking
- pot-shape, material, size etc.

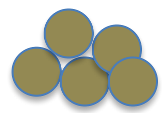
Design principles of stoves per fuel type

Substance:	Uncarbonised, natural		carbonised
Shape:	**Log-shape** pushed from side	**Small size Lumps / Chunks** cannot be pushed but poured in a container	

Fuel: e.g. FIREWOOD

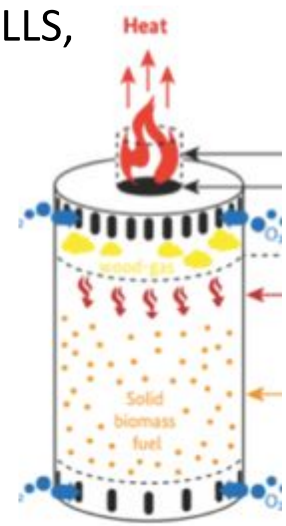


Design principle:
Continuous side feed
Rocket stove

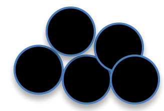


Fuel: e.g. NUTSHELLS,
WOODCHIPS,
PELLETS etc.

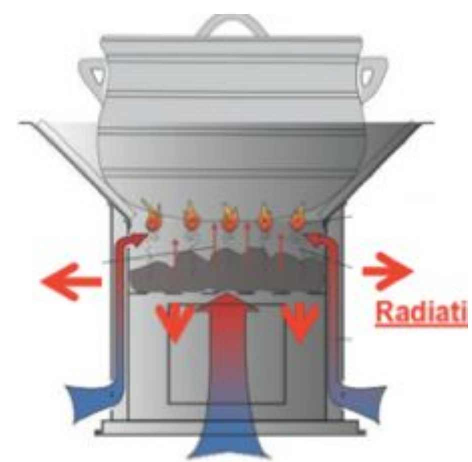
Design principle:
Batch-fed
TLUD gasifier



Fuel: e.g. CHARCOAL

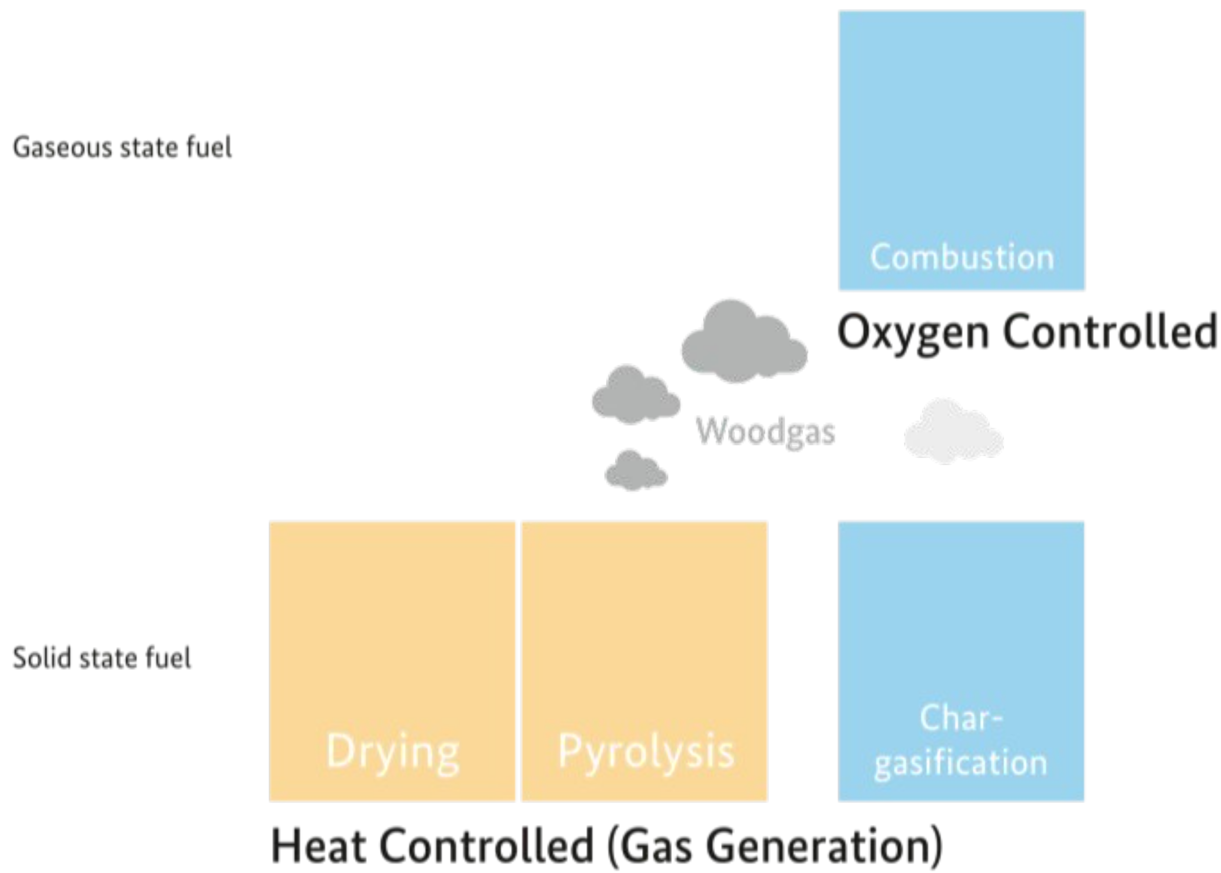


Design principle:
Batch fed
Charcoal stove

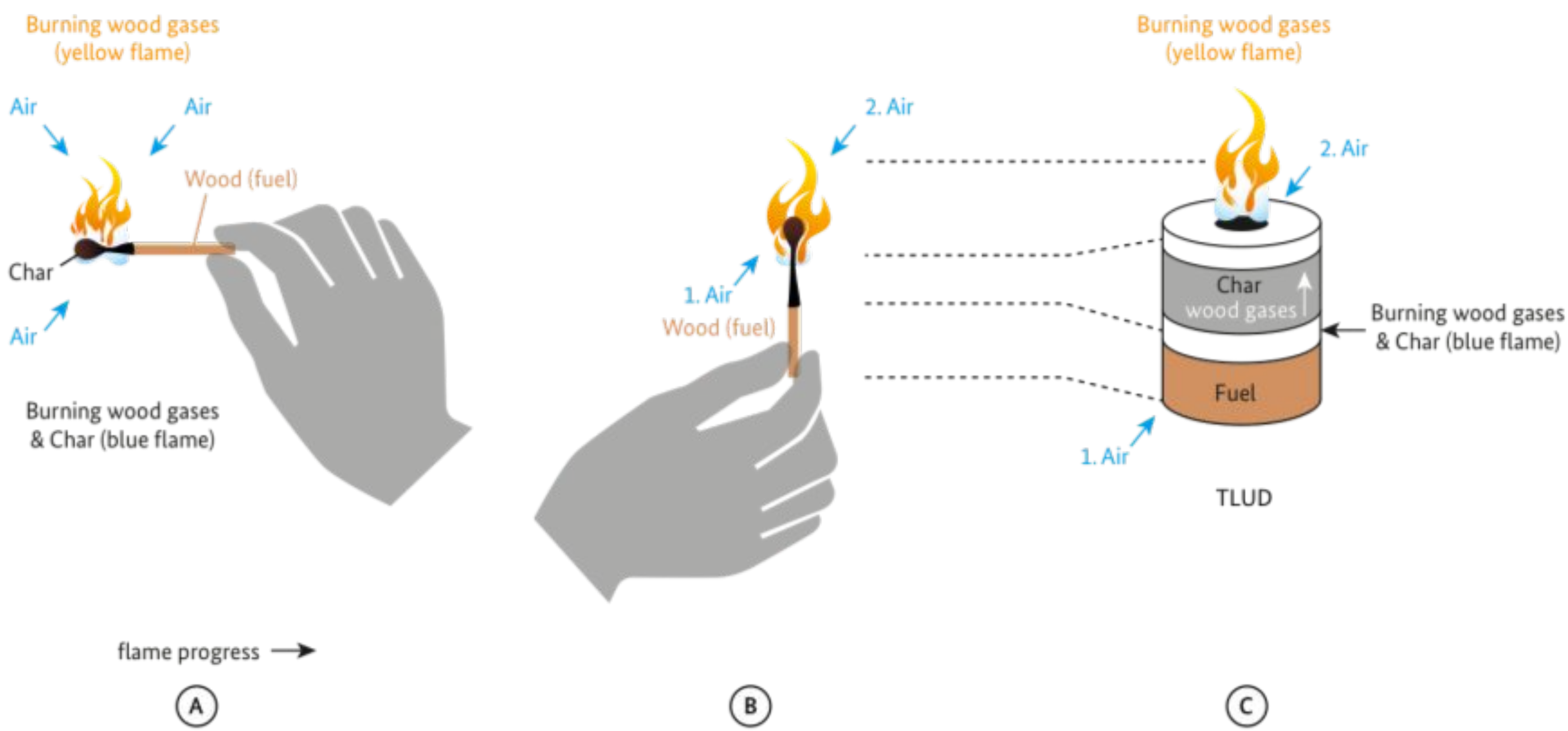


For all other small-size natural and processed fuels:

Gasifier: gas-creation seperated from gas-combustion



Top-lit Up-draft gasifiers: char-making gas-generator below, gas-burner on top



Gasifiers

Options for multiple paradigm shifts

1. Charcoal production
2. Urban biomass cooking fuels
3. Biochar for CCS (carbon capture and storage)-

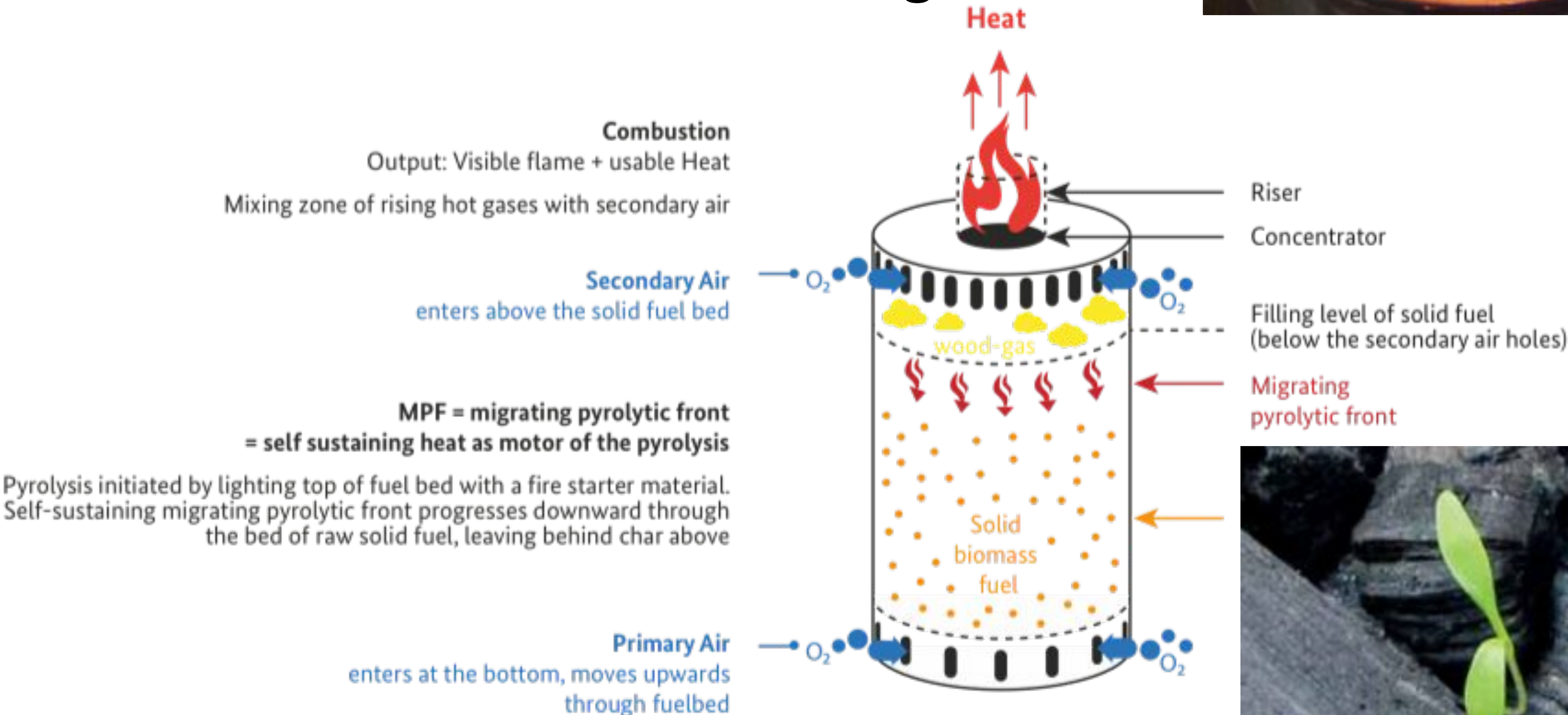
= climate change mitigation&adaptation

„Using fire to cool the Earth“ (quote Bates/Draper)

Gasifier: A paradigm shift **for charcoal production and urban cooking fuels**

1

= mini-kiln that turns small chunky biomass into char while cooking

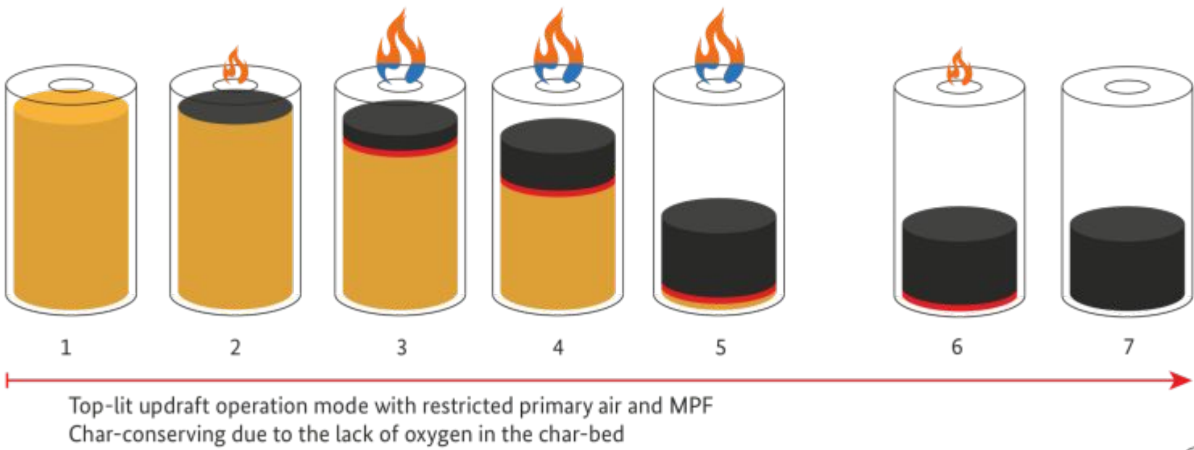


Gasifier: Batch-feeding of fuel, heat controlled by air regulation
Conventional fires: constant feeding of fuel, unregulated air-supply

User can decide by **control of air** what to do with the char

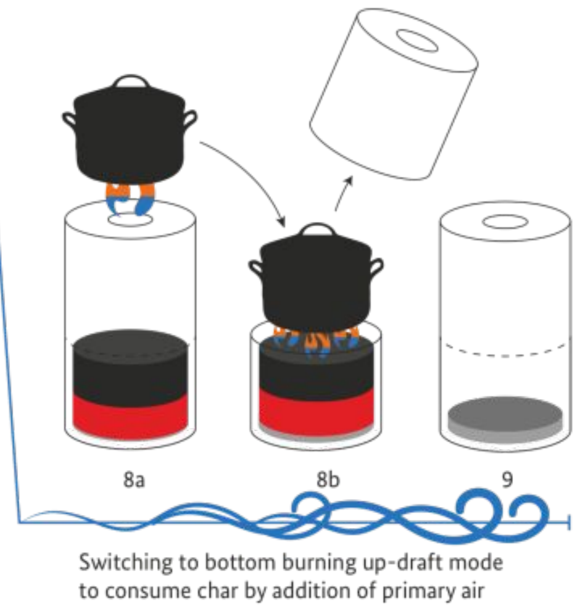
No air = Conserve char

- Earn-as-you-cook (charcoal buy-back)
- Use as biochar = climate-friendly carbon-negative cooking = CCS (carbon capture & storage)



Add air = burn char to ash

- Making own charcoal under the pot while cooking
- Utilisation of all primary energy of natural resource
- Ideal for cooking habits with extended simmering phases



Tchar-concept

1

‚TChar‘: Combing multiple options

Gasifier produces own char on top of a charcoal stove, for immediate use in charcoal stove while still hot

Processing&densifying biomass for predictable and optimised clean combustion

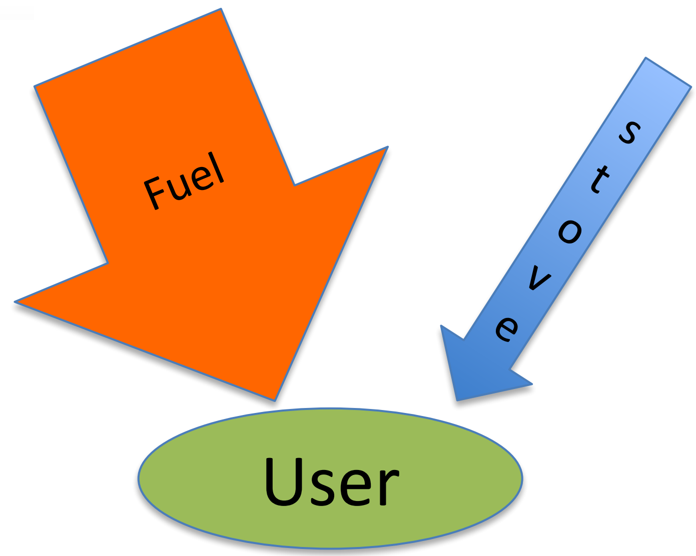
2

“Like cooking on gas”

Ideal for clean cooking with biomass in urban areas

Supply chain management is crucial!

- **Fuel supply is most time-sensitive and is needed in the appropiate quality and quantity on a regular / daily basis (unlike stoves)**
- **Logistical challenges of transport of input materials and product**
- **Power dependency and requirements for processed fuel production**



For cooking user needs both at the same time

Biochar

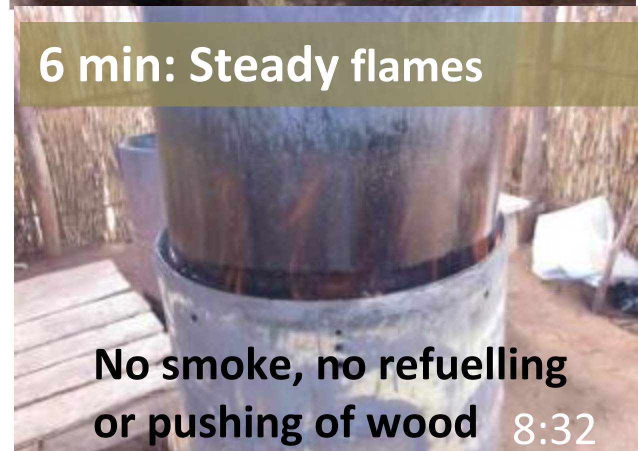
3

example from Malawi of gasifier dimensioned to cook 50 liters of porridge with loose maize cobs

aMaizing cooking

- Replaces firewood with farm residues
- Produces biochar for nursery substrate
- Captures and sequesters carbon –

"Using FIRE to cool the Earth"



Biochar -

Natural carbon sequestration & safe storage with lots of other benefits e.g.

- Restore damaged soils and revitalize soil life
- Make crops healthier and more resilient to climate change, improve yields
- Reduce acidity and bind contaminants that potentially enter the water and food chain

Also application in water filters for safe drinking water, etc. etc…

Biochar is an ideal tool for

- Climate change **mitigation**
- Climate change **adaptation** for improved climate resilience of agriculture and food security

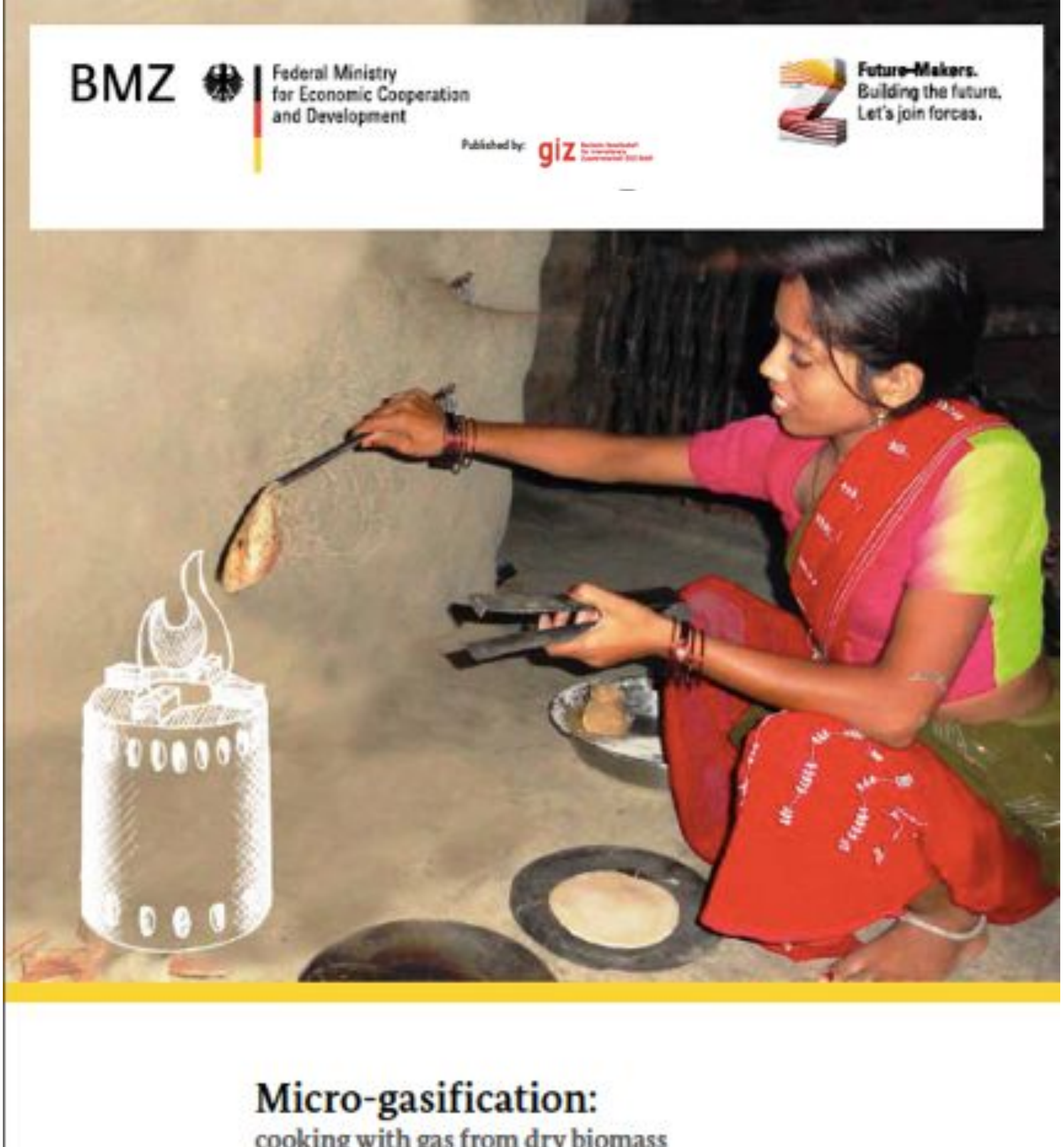
Sieving: large pieces = easily igniting charcoal

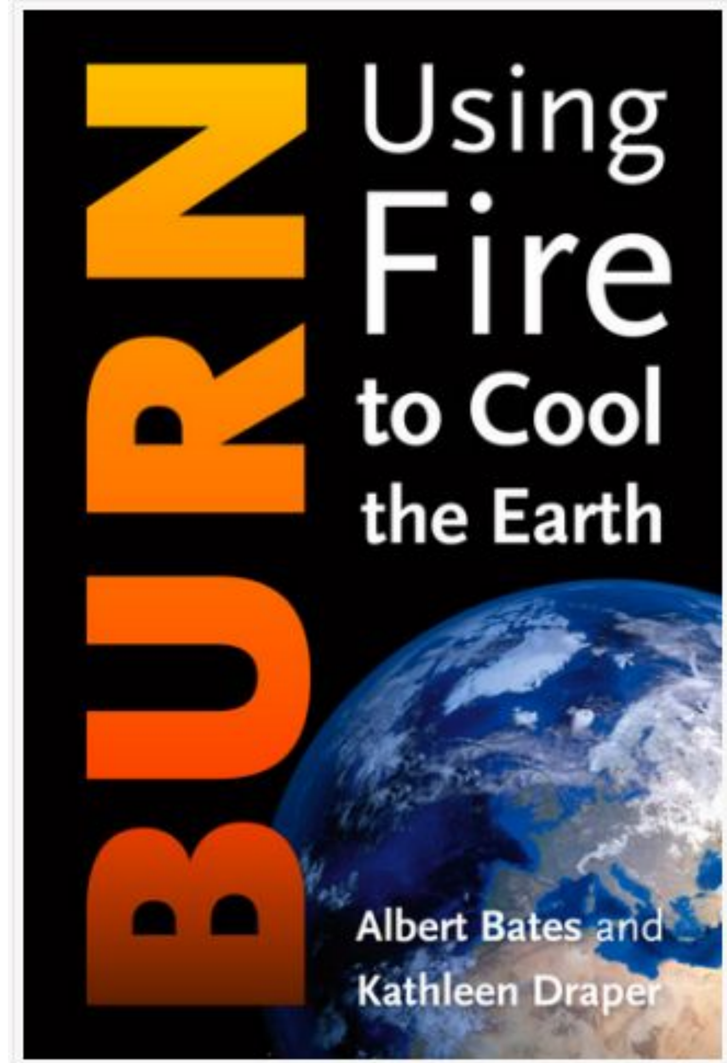
Small pieces for biochar = priming with microbes and ready to go into the soil

3 major takeaways on Gasifiers

1. Charcoal production can be shifted under a cooking pot to utilise all primary energy of biomass (Mitigation: avoided emission from traditional charcoal production)
2. Ideal option for clean cooking on renewable gas from processed biomass (e.g. pellets) in urban areas (instead of fossil LPG)
3. Biochar = soil improvement to produce more food = no-risk natural CCS (carbon capture and storage)
   - Mitigation - Using fire to cool the Earth
   - Adaptation – increase resilience&food security

Further reading





https://energypedia.info/wiki/File:2014-03_Micro_gasification_manual_GIZ_HERA_Roth.pdf

https://energypedia.info/index.php/GIZ_HERA_Cooking_Energy_Compendium