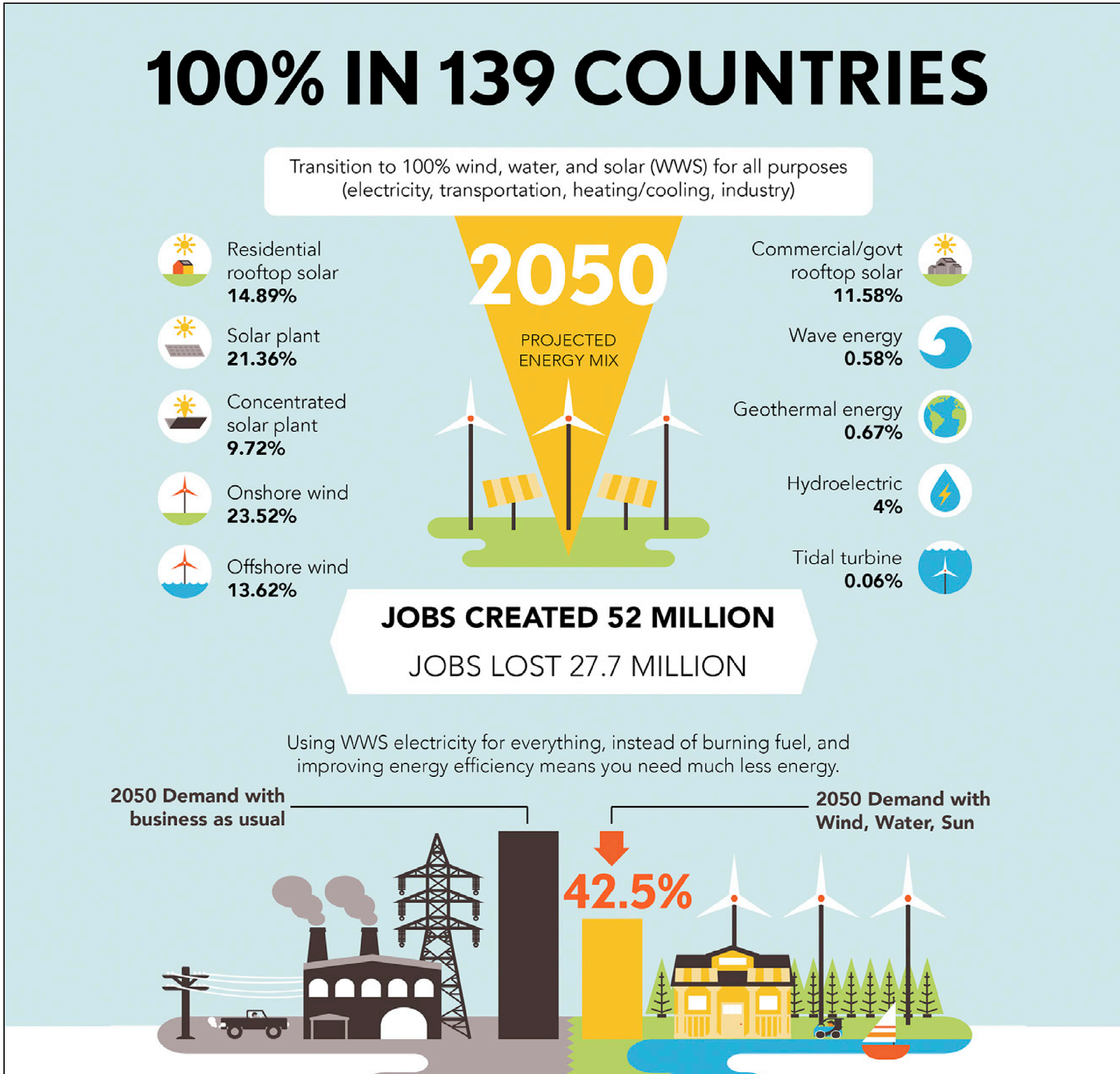
Is biomass part of the solution?



Source: The solution Project

Wind, Water and Solar. But why not biomass? Mainly for the pollutant emissions. But they can be overcome.

Cons

Pollutant emissions

Land use competition

Resource availability

Deforestation

Water requirements

Pros

Locally available

Various feedstocks

Versatile use (heat, electricity, fuel)

Waste reduction

Storable energy

source: bioenergycrops.com

According to WHO : 4.3 million people a year die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels (2012 data) for cooking.

A locally manufactured gasification technology for the valorization of agricultural wastes in West African countries

Hervé **Jeanmart**[1], Séverin Tanoh[2], Wilfried Ouedraogo[3], Yohan Richardson[2], Sayon Sidibe[2], Frédéric Bourgois[1], François Pinta[4]

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Support of ARES-CCD is gratefully acknowledged

Sustainable Energy for Africa - Brussels - October 23-25, 2017

A locally manufactured gasification technology for the valorization of agricultural wastes in West African countries

- Which resources?
- What is gasification?
- Combustion vs Gasification
- Gasification Technologies
- Local technology
  - Gasifier
  - Gas cleaning unit
- Future Developments

Which resources?

What is gasification?

Combustion vs Gasification

Gasification Technologies

Local technology

- Gasifier
- Gas cleaning unit

Future Developments

There are many sustainable biomass resources. Agricultural residues have a great potential in West Africa.

Availability in Burkina Faso

Cotton stalk	900 000 tons
Rice husk	63 000 tons
Cashew nut shell	50 000 tons

+ Millet stalk, Sorghum stalk, etc.

Cotton stalk conversion into electricity could cover 20% of Burkina Faso electricity needs. But heat demand is also large (rice parboiling, cashew nut roasting, dolo production, etc.)

Which resources?
What is gasification?
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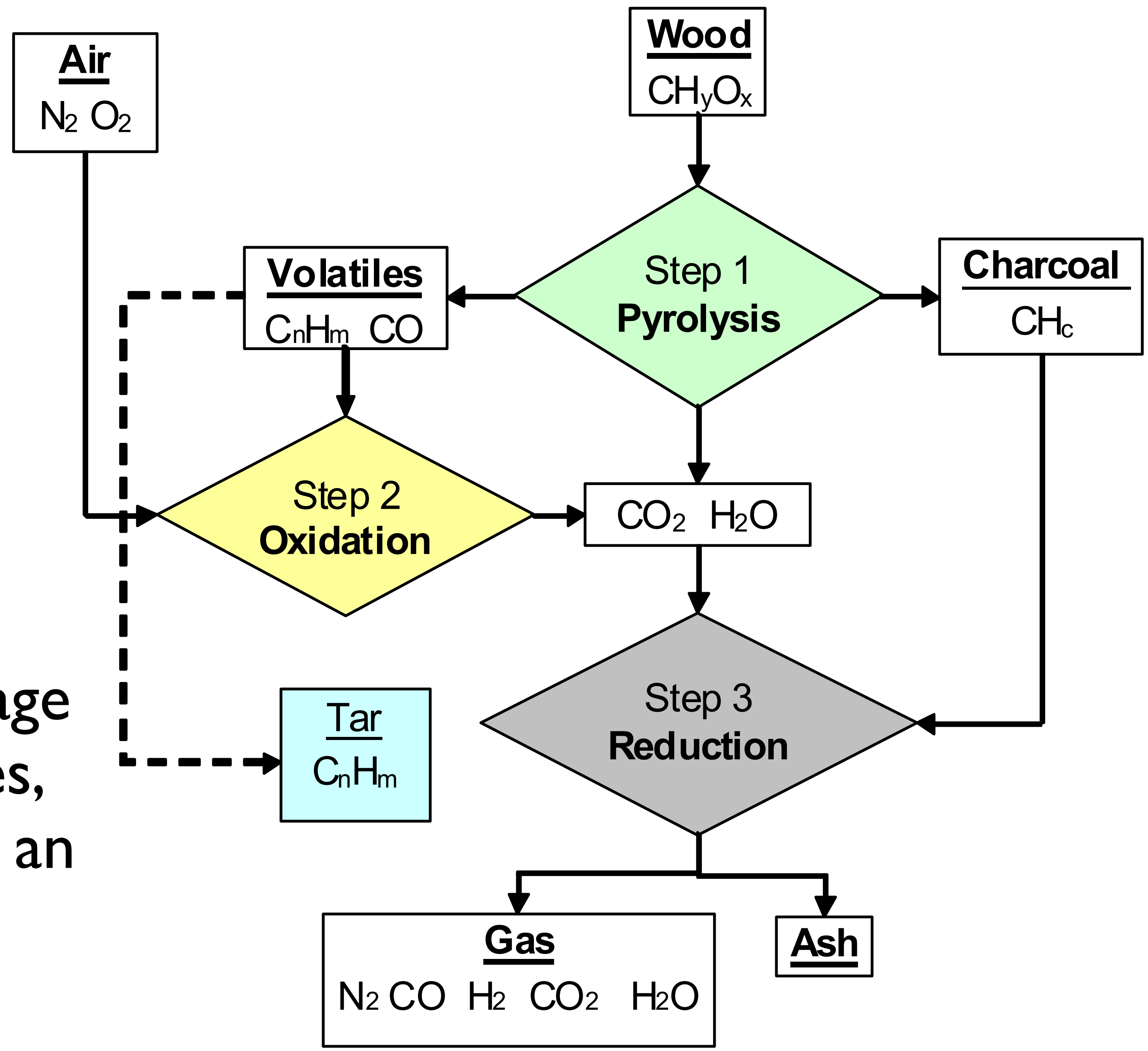
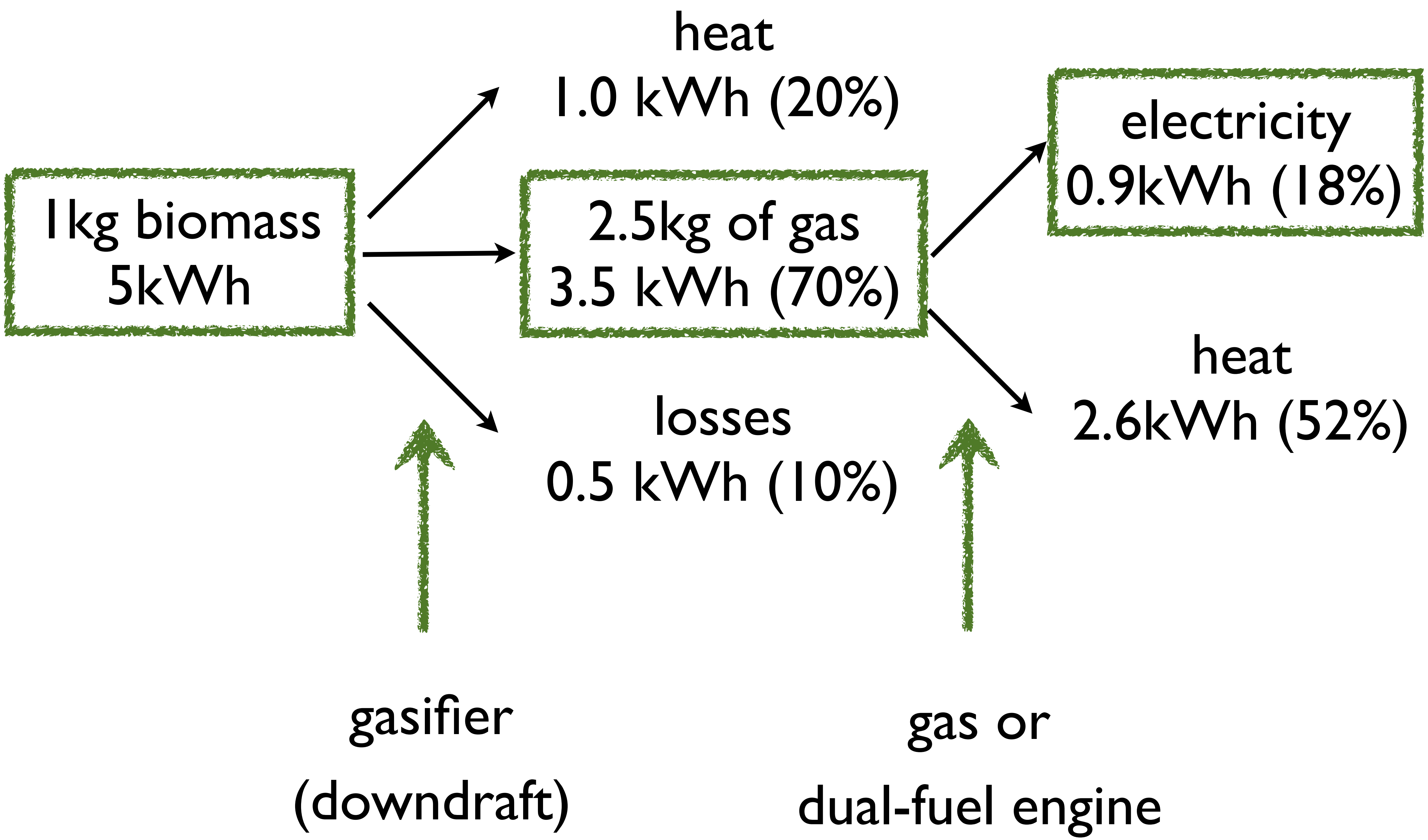
Future Developments

Gasification is a high efficiency conversion of a solid into a combustible gas, mainly composed of CO and H2.

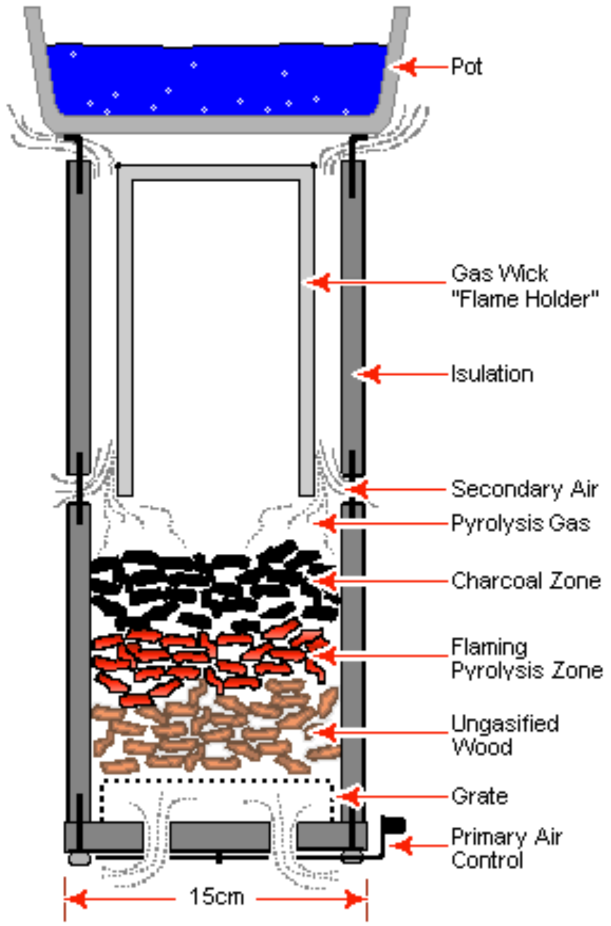


In single-stage approaches, tars remain an issue

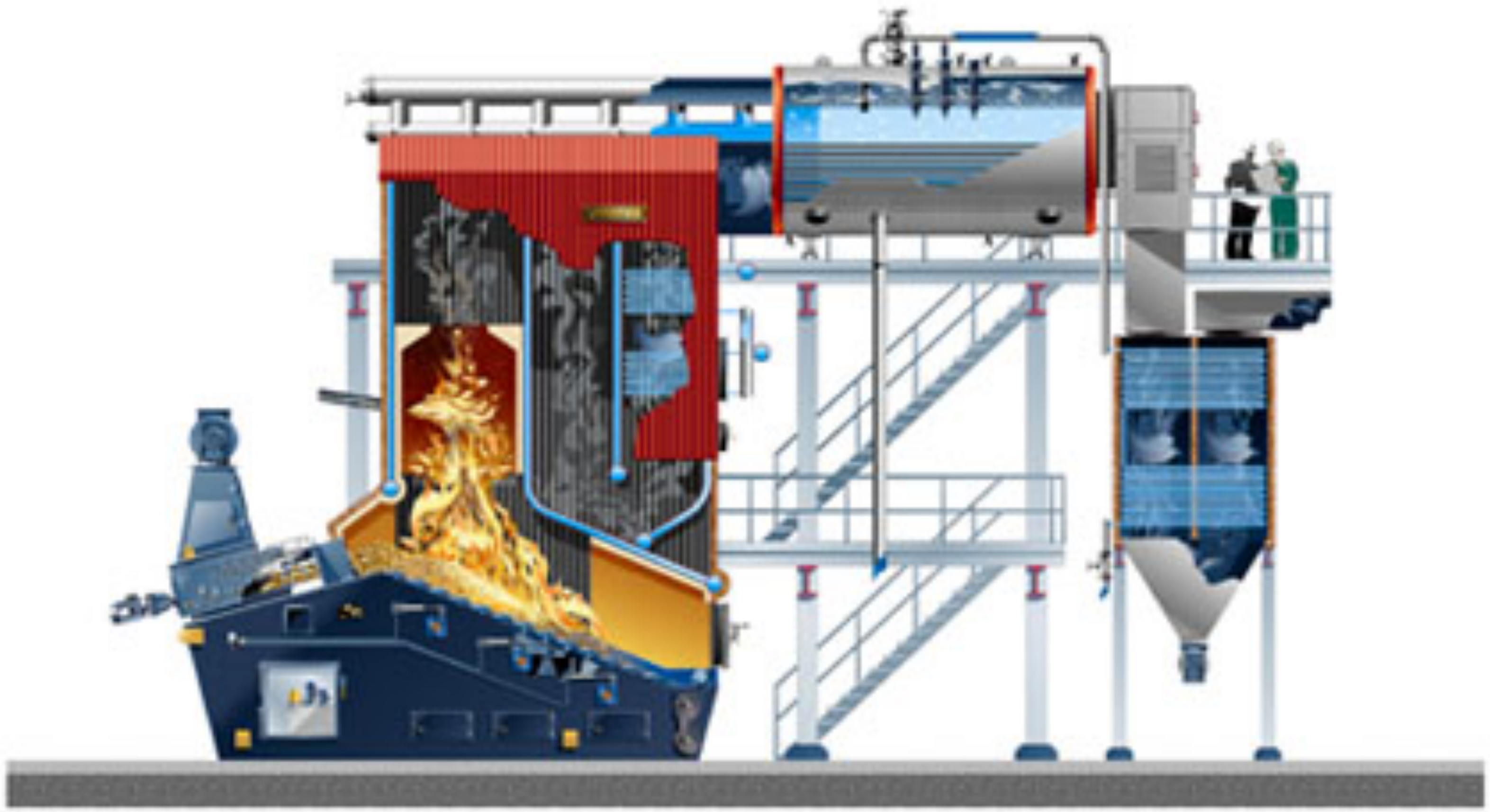
Cold gas efficiency is 70%. The gas can be further converted into electricity with an efficiency of around 20%



Gasification is also the first step in all modern combustion appliances



Improved cookstove



Large scale biomass boiler (Vyncke)

Which resources?
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For residues, at small scale (<100kWe), gasification is an advantageous conversion route compared to direct combustion

		Fossil fuel boiler	Biomass boiler	Gasifier
Fuel	Gasification is more versatile but requires a more thorough biomass pre-treatment	+++	+	+
Usage	Gas has multiple usages	+	-	++
Emissions	No net CO2 emissions for biomass Less emissions with gasification	- -	-	++
Costs	High CAPEX for biomass boilers and gasifiers High OPEX for fossil boilers Higher maintenance costs for gasifier	+	-	- (-)
Maturity		+++	++	-

Which resources?
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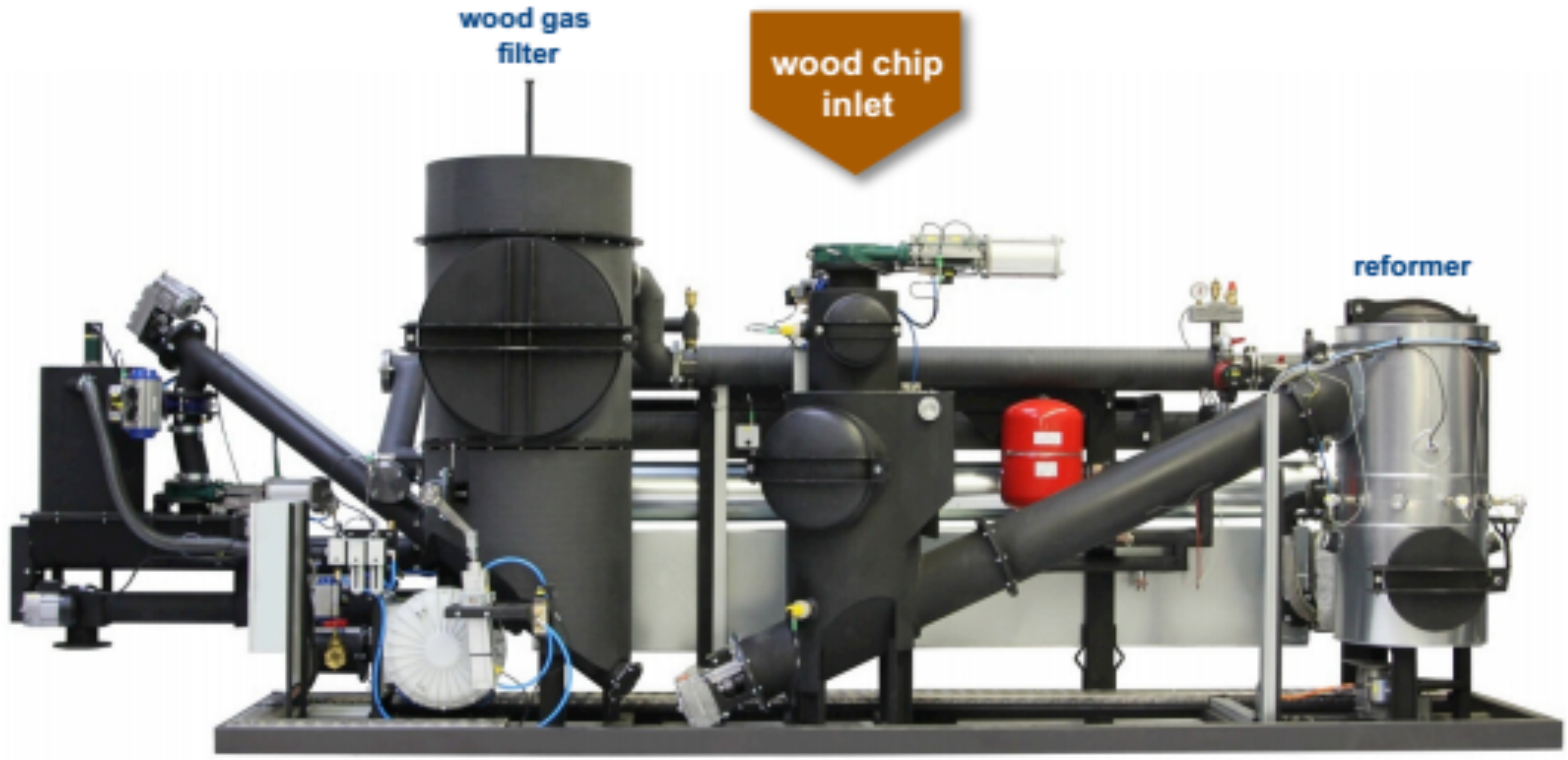
Fully-automated european technologies are too complex and unaffordable even if they have the right nominal power



Spanner technology (Germany)

Quite expensive imported technologies (mostly from India) with contrasted experiences


Dano : 41k$ for 24kWe (run for a few hours only, pictures above)

Pô : 60 k$ for 22 kWe (run for 1000 hours without major issues, stopped for economical reasons)

- Which resources?
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Our approach to develop a local gasification technology

Local expertise

Formation (Internship, PhD, etc.) of masters and technicians
Research activities oriented towards local applications
Local cooperation (between research entities, industries, etc.)

Local technology

Material availability as a starting point
Collaborative design based on local manufacturing techniques
Realistic and adapted technical objectives (efficiency, effluents, etc.)
Locally developed command and control with limited imported systems
Local development of measuring techniques (tar concentration)

Local needs

Regular discussions with all stakeholders (farmers, researchers, manufacturers, NGO, etc.)

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Local economic activity and value added

Main components of a gasification facility? Which objectives for a small-scale system (<100kWe)?

Availability of the facility (5000 h/y)

Low Effluents (tars, water, etc.)

Fuel flexibility (residues)

Local Manufacturing (80-100%)

Operation (mainly manual)

Elec. Efficiency (1kg biomass/kWhe)

Feedstock

Gasifier

Gas Cleaning Unit

Combustion

Engine

Combustion

Main components of a gasification facility? Which objectives for a small-scale system (<100kWe)?

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Feedstock

Locally manufactured gasifier and cleaning unit

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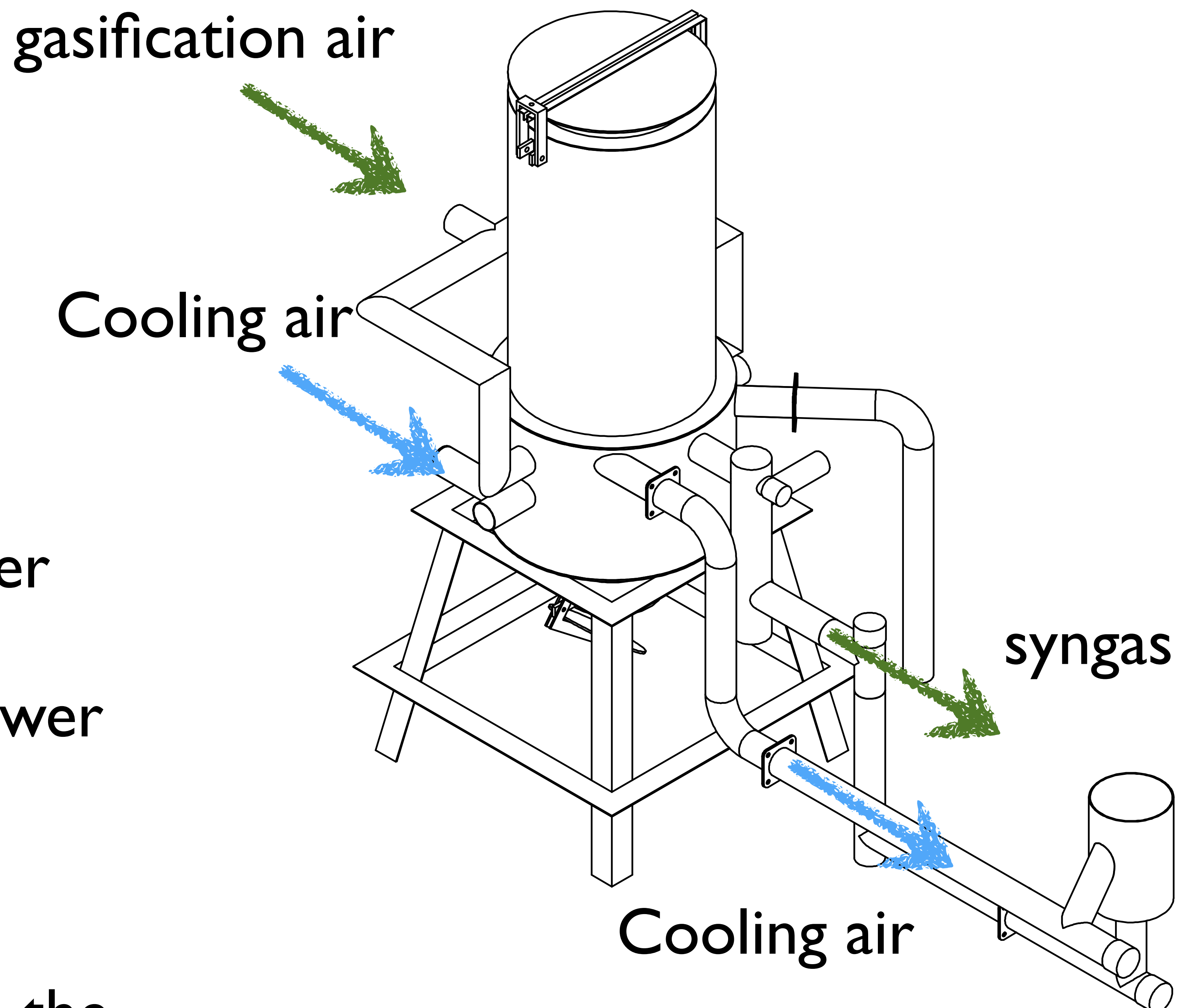
The gasifier is based on a design by the ISOMET society in Burkina Faso



Rice husk gasifier (100kWth)

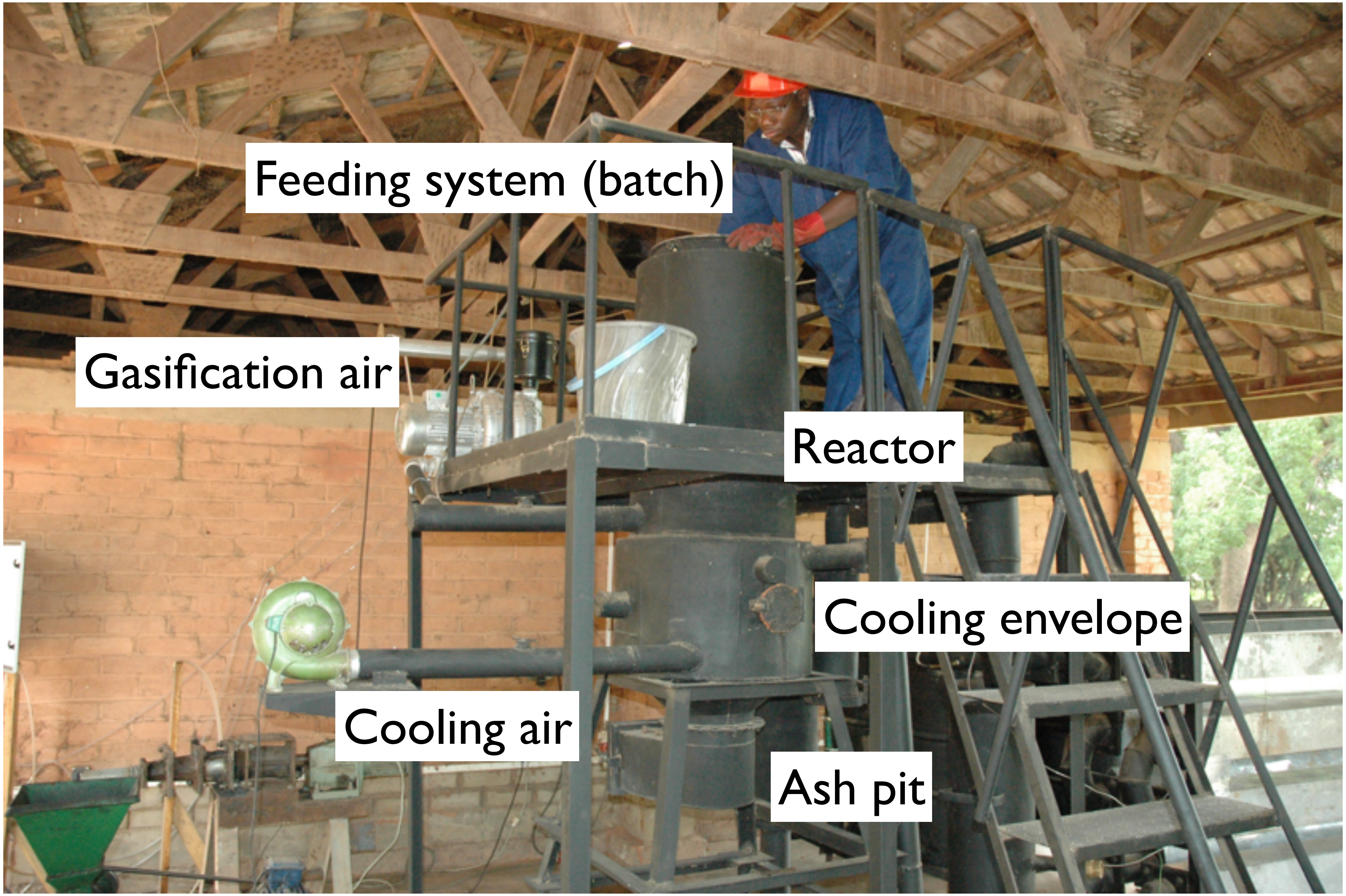
Batch (25kg) downdraft gasifier

Gasification air is fed by a blower

Cooling envelope

Complex welded joints inside the gasifier behave badly under thermal constraints

It has been modified and improved to better control the air mass flow rate and reduce leakages

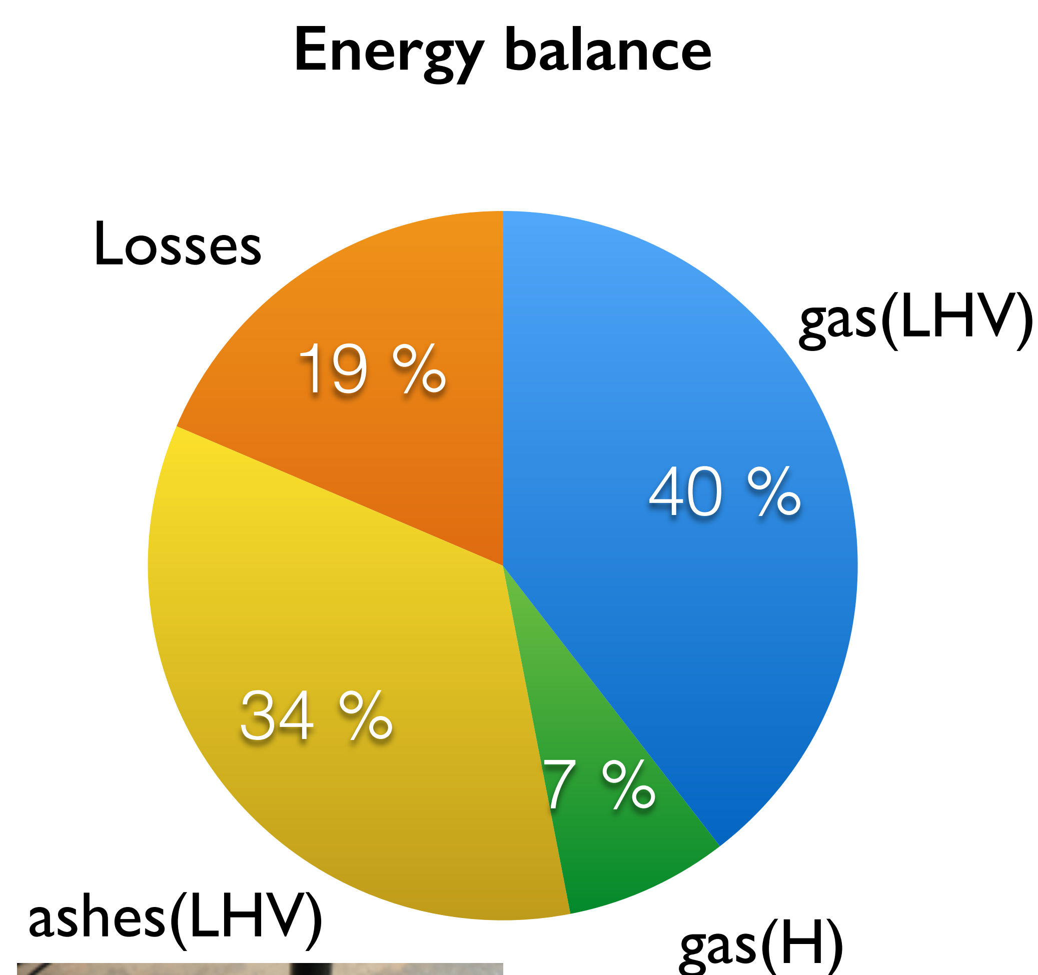


Raw gas coming out the ash pit due to air tightness issues. Leakages due to manufacturing quality remain one of the major issues

Gasifier mass and energy balances : limited biomass conversion leading to high losses in the ashes (unconverted biomass)

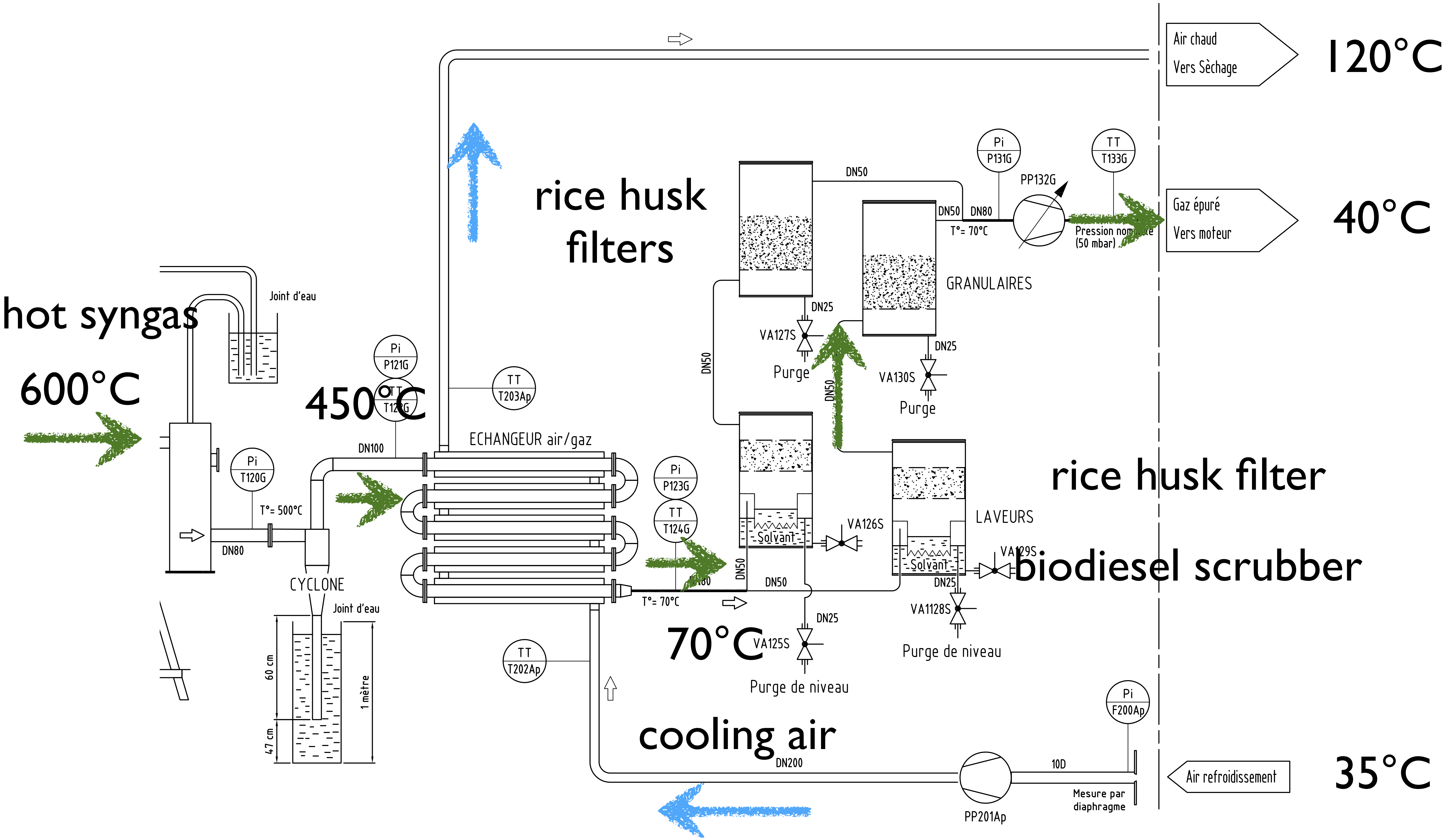
IN		
	(kg/batch)	(MJ/batch)
rice husk	24	342
air	52	0
ashes	3.5	35
OUT		
	(kg/batch)	(MJ/batch)
gas (LHV)	62	14
gas		28
ashes	13	130
LHV	(kJ/kg)	
rice husk	14250	
ashes	10000	

Source: Rodrigue Neya

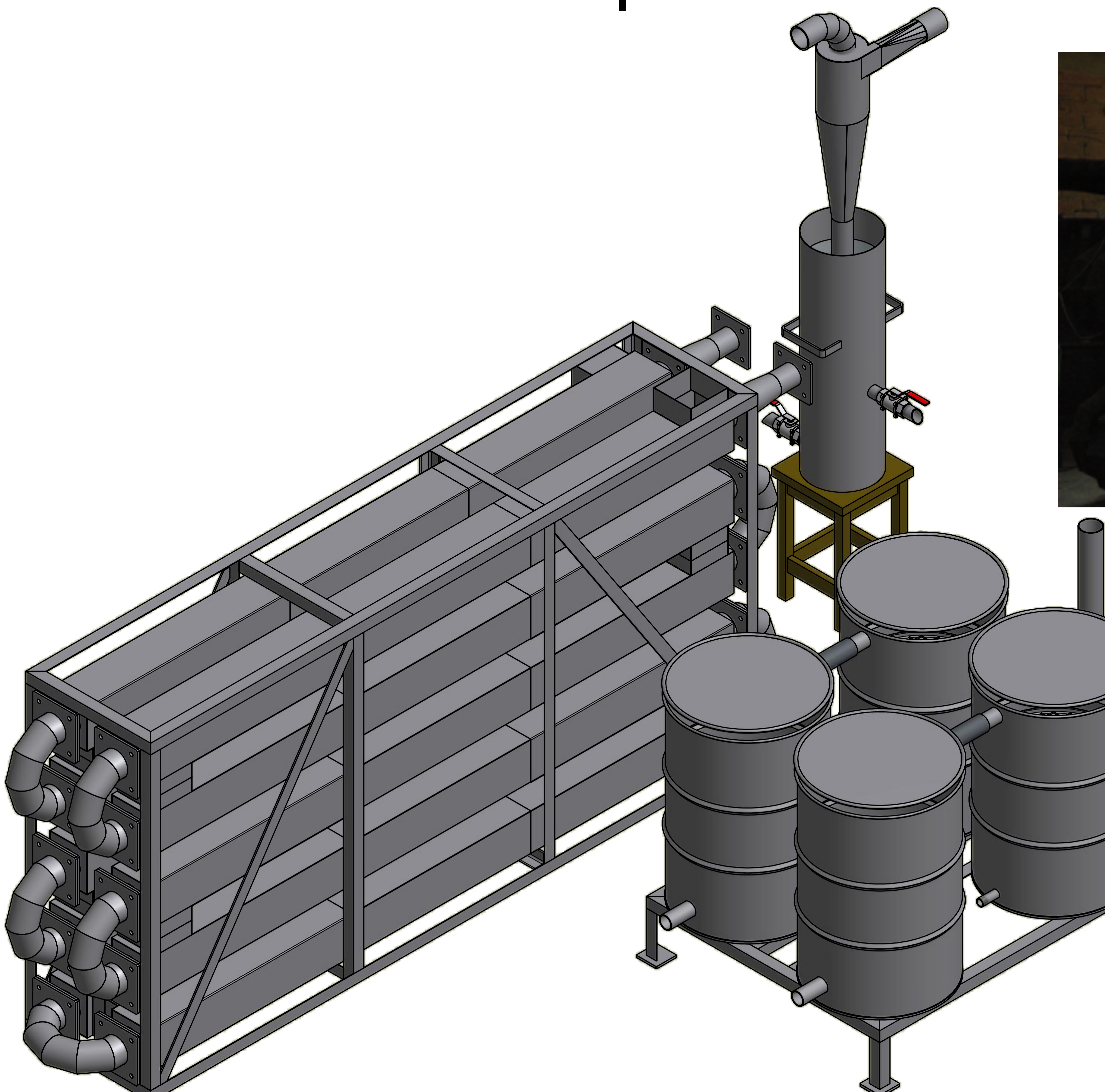


Biomass conversion efficiency must be improved. This requires a new design.

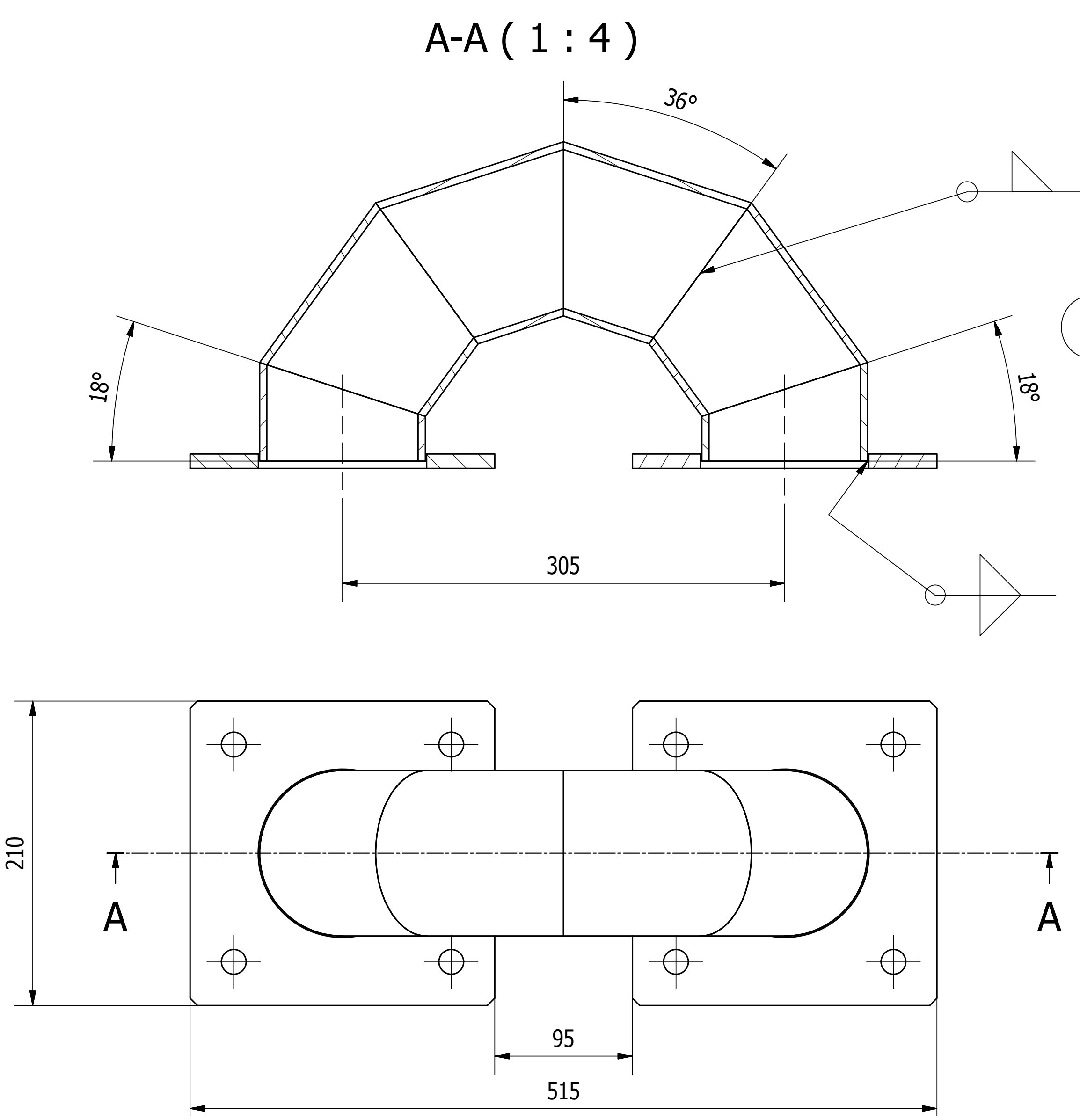
Layout to ensure a cold and tar free gas at the outlet based on a tubular heat exchanger, a biodiesel scrubber and rice husk filters

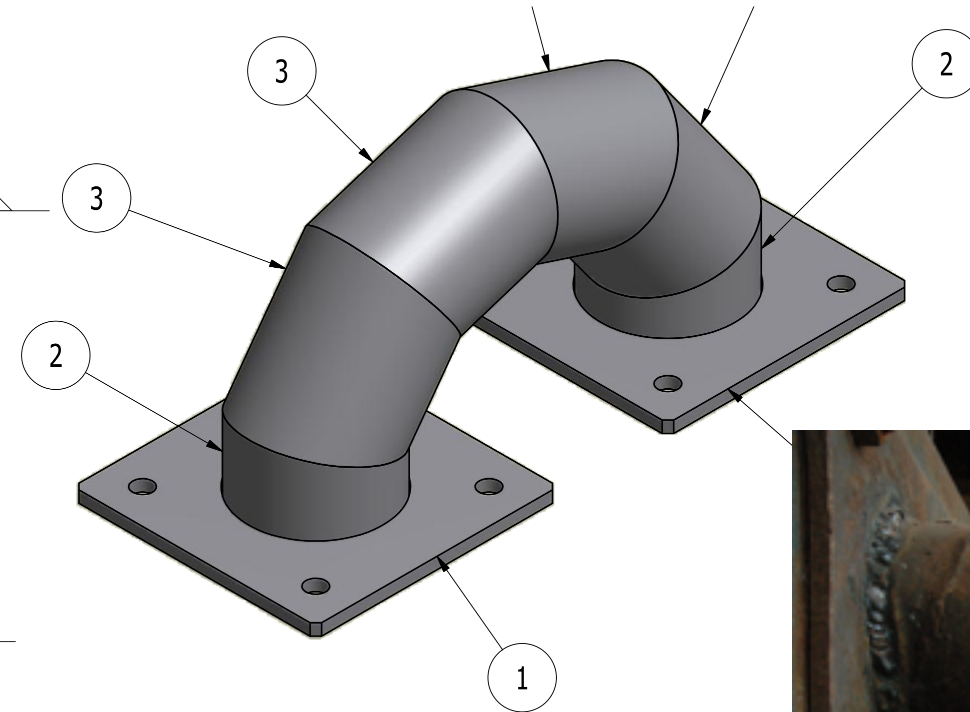


A dry cleaning unit to minimize the effluents : no water or other liquid added to clean the gas



Manufacturing 180° bends (and many other parts) remain a challenge requiring specific skills

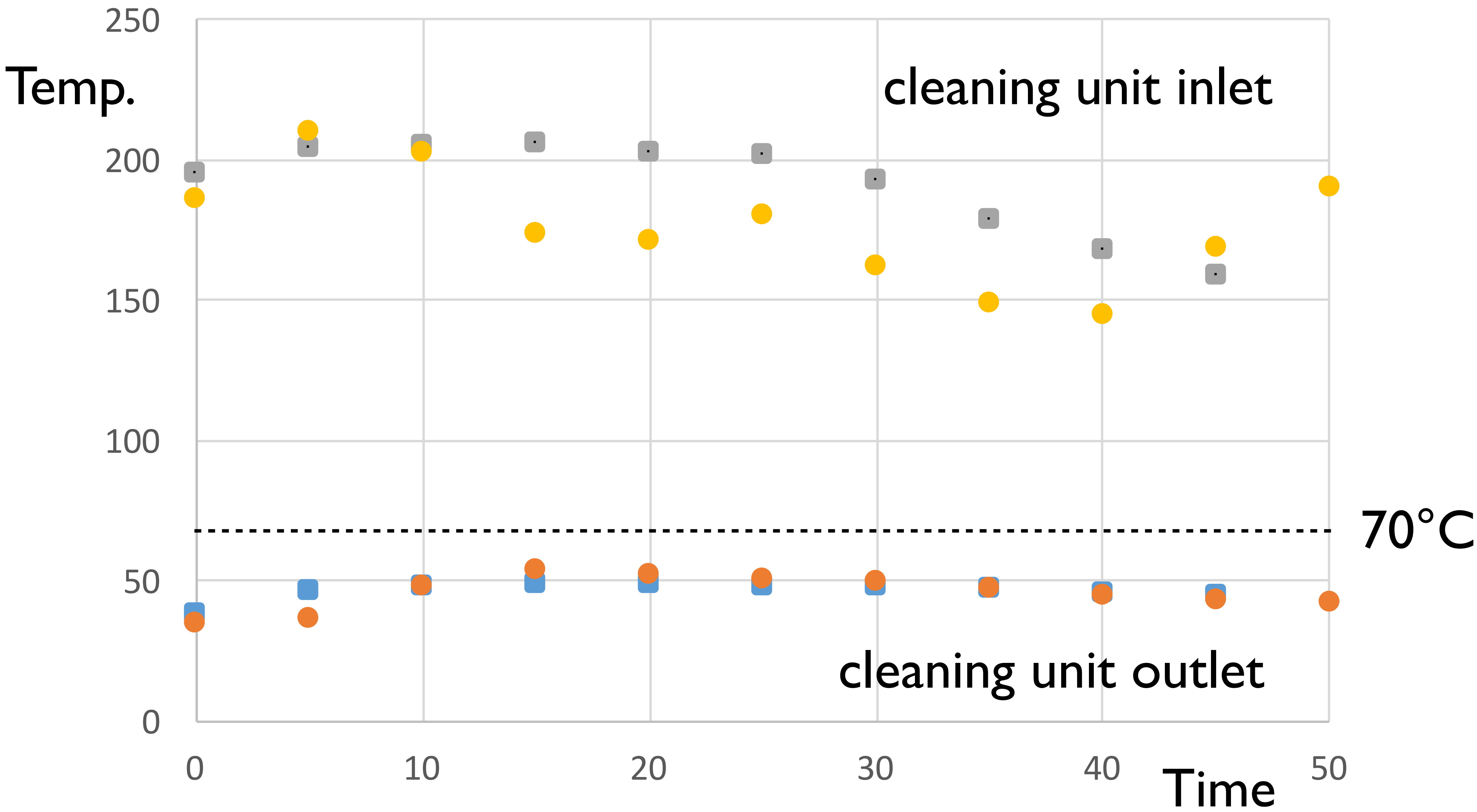




multiple welded joints increase the risk of syngas leakage for gasification under slight pressure

High gas quality (clean gas) leading to a nearly invisible and low emission flame but more measurement equipments are needed

Gas cleaning unit performances : inlet temperature is too low leading to the partial condensation of tar and water in the heat exchanger.



To sum up

Biomass (agricultural residues) is available and suited for energy purposes both heat and electricity

Gasification is a low pollutant alternative to direct combustion

A locally designed and manufactured technology has been assessed

Gasification of rice husk has been partially successful

The gasifier and the cleaning system must be further improved

Ongoing developments

Work on the gasifier design to increase biomass conversion and reduce thermal constraints

Study of the social and economic feasibility of the gasification conversion route in Burkina Faso

Development of a dual-fuel engine matching the batch gasifier characteristics

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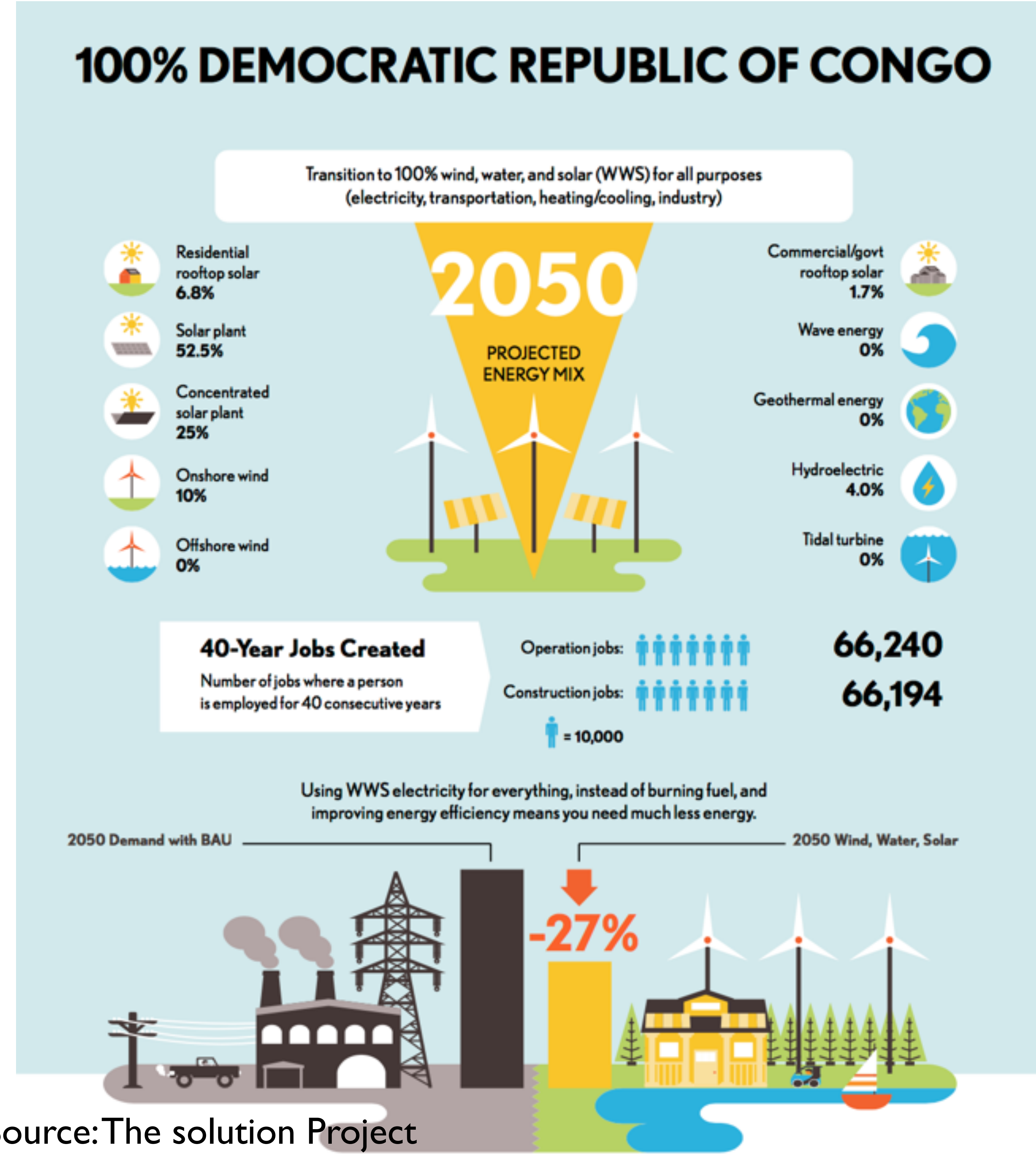
Abstract

Rural populations in Africa depend nearly exclusively on woody biomass to satisfy their energy needs that are usually limited to cooking and some food processing. Nevertheless, this limited use together with the biomass exported to the cities lead to an unsustainable pressure on the resources. At the same time, agricultural activities lead to the production of large quantities of residues (cotton stalk, rice husks, etc.). These wastes have an energetic potential that could be exploited locally. But, contrary to woody biomass, the combustion of these residues is complex. Gasification could help converting efficiently these residues into more useful forms of energy: not only heat but also electricity. Downdraft fixed bed gasifiers are the most suitable technology for the range of power (50…200kWth) and feedstocks considered. While gasification could significantly improve the access to energy in rural areas, the imported technologies (e.g. from Europe and India) are too complex and thus not resilient. Existing local technologies do not sufficiently take into account the peculiarities of the gasification process and of the available feedstocks. A technology designed to be efficiently manufactured, operated, and maintained locally could overcome the barriers that prevent the development of gasification in rural areas of West African countries. Such a concept entails many challenges. The characteristics of the feedstocks, especially the moisture and ash content, may vary a lot. The quality of the available steel makes it unsuitable for high temperature processes and prone to corrosion. The local manufacturing techniques must be adapted to produce airtight vessels from available parts. The cooling and cleaning requirements for the syngas must be matched without producing hazardous liquid effluents. Yet the numerous challenges can be overcome with suitable designs for the different parts of the gasification facility. After a description of the potential contribution of agricultural wastes to the energy needs in rural Africa, these challenges shall be detailed and illustrated with results, including experimental data, taken from the development steps of a gasification technology manufactured in Burkina Faso for the production of heat and electricity.



Source: The solution Project