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Fast and gentle solar-sorptive drying of fruit and spices with energy efficient water recovery

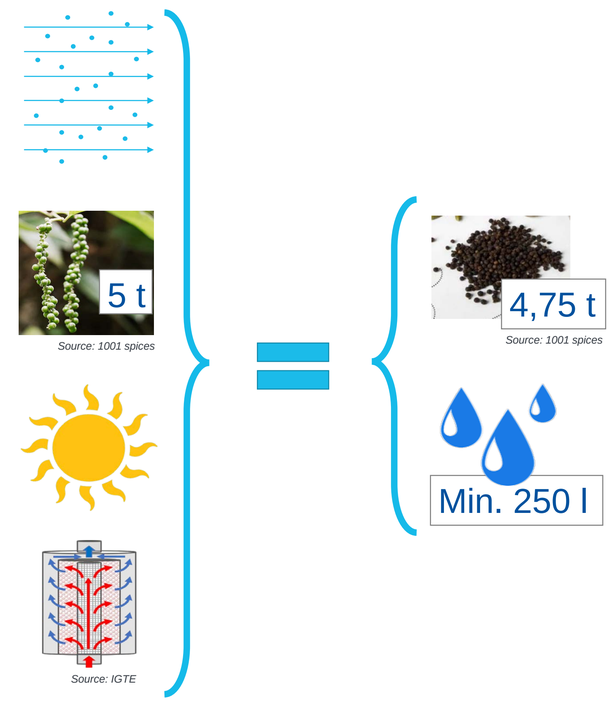
Background and Objectives:

Zanzibar is one of the largest suppliers of spices and fruits in the world. Yet there are several challenges to face:

Figure 1: traditional drying of cloves on the street (top), inflatable tunnel dryer (centre) spices of Zanzibar (bottom)

- **Traditional drying** of spices (e.g. cloves, pepper, cinnamon, ginger, vanilla, cardamom, nutmeg) on the road **takes several days**
- **Contaminants** such as dust, stones, insects, mould and germs **reduce the quality**
- Existing **inflatable tunnel dryers** are **not used** due to the lack social acceptance
- **High humidity** of the ambient air requires **high drying temperatures** in existing glasshouse dryers
  → **additional heating required**: fossil fuel (figure 1 centre) or electrical (infrared heating) having a negative impact on the quality of the produce
- **Limited access to safe drinking water:** water is contaminated with germs or salinated by seawater

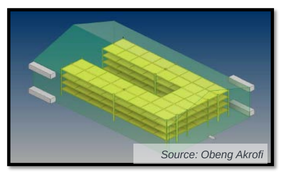
⇒ New process for efficient and gentle drying of food with subsequent water recovery has been developed to address these challenges



Method:

Solar-only driven concept by combining greenhouse dryer with adsorption process:

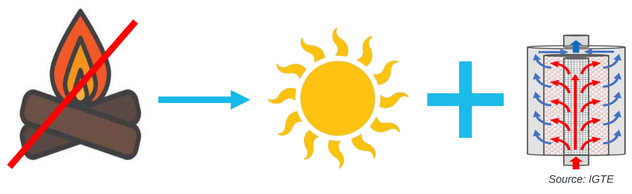
- Enhancement of the 5 t capacity Solar Hybrid Dryer from former project Evergreen in Ghana



- Several drying levels on 4 to 5 shelves for different types of produce to be dried

Figure 2: Solar Hybrid Dryer by G2Josh Evergreen

- Replace fossil fuel (oven) by solar-sorptive concept (solarthermal collector, photovoltaic cells and sorption reactor)



Benefits of concept:

- Pre-dried air **takes up more moisture** from the produce
- Gentle **low temperature drying** for sensitive produce to preserve valuable flavours and etheric oils
- **Accelerated drying process** (< 48 h)
- Reduced risk of mould and germs
- **No fossil fuels** or additional electricity required
- **Recovered water** can be used as drinking water or for washing the produce to be dried

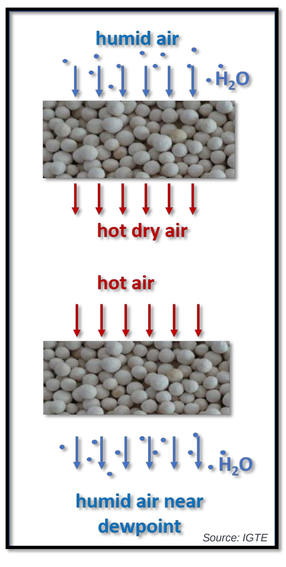


Figure 3: adsorption (top) and desorption (bottom)

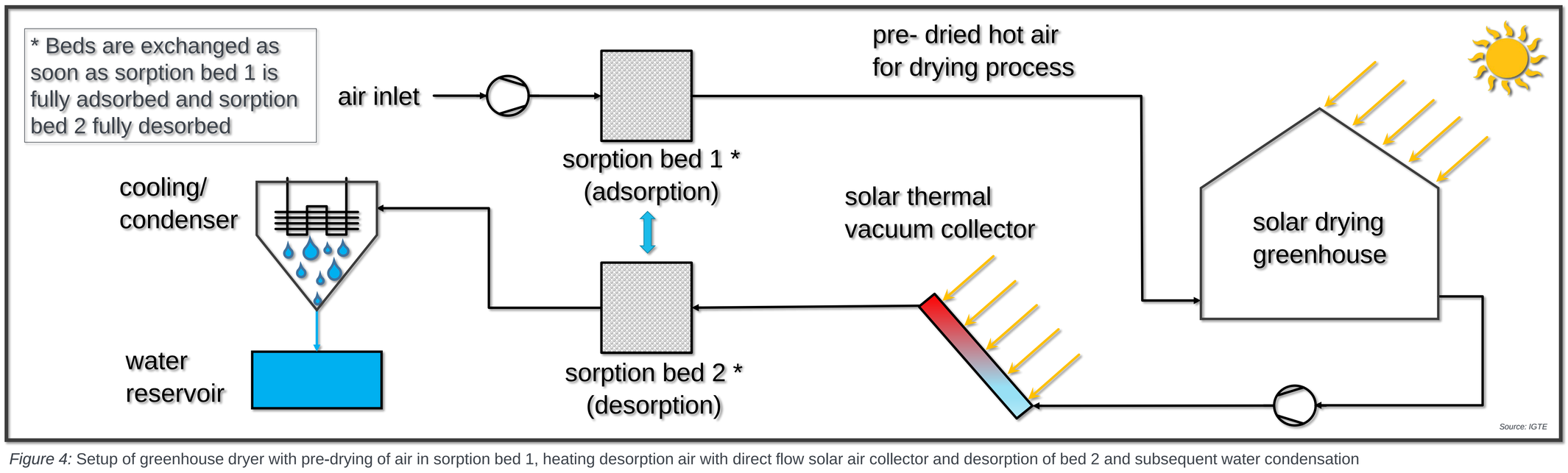


Figure 4: Setup of greenhouse dryer with pre-drying of air in sorption bed 1, heating desorption air with direct flow solar air collector and desorption of bed 2 and subsequent water condensation

Results:

First results from small scale lab demonstrator for solar-sorptive water generation from arid air

- Desorption and condensing process only
- Small air stream (25 m³/h),
- Adsorption at 8 g water/kg air
- ~5 ml of drinking water condensed per kg desorption air stream
- With drying process as humidity source, higher water recovery rates are reachable

⇒ For drying of **5 t pepper, min. 250 litres** of water are expected

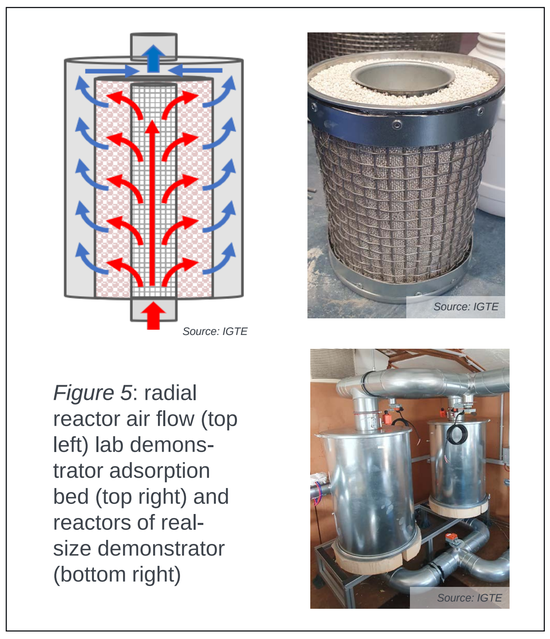


Figure 5: radial reactor air flow (top left) lab demonstrator adsorption bed (top right) and reactors of real-size demonstrator (bottom right)

Conclusion and Outlook:

- Demonstration for water recovery successful at lab scale
- Drying process has to be adapted and optimised to sorption process
- **Real-size demonstrator of water generator** is **being built** at IGTE to produce water directly from ambient air
- **On-site demonstrators in Zanzibar and Tanga** with complete set-up of greenhouse, drying shelves, solar collectors and sorption system are **aimed** for validation and optimisation (applicability, efficiency, costs and social acceptance)

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