# Vegetable oils as heat transfer fluids: literature review and thermal aging study under inert atmosphere

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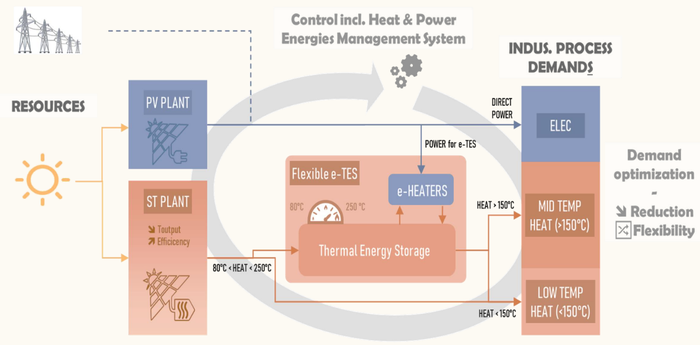
## CONTEXT

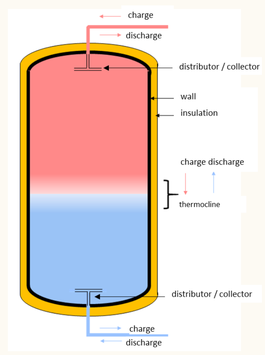
Thermal Energy Storage (TES) [1]
- Chemical
- Latent → Phase Change Materials
- **Sensible → Heat Transfer Fluid (HTF)**

Solar Heat for Industrial Processes (SHIP)
- 74% of the total industrial energy demand stemming from heating [2]
- Most industrial processes use temperatures up to 250°C, particularly in [100 ; 200°C] [2]

INDHEAP EU project
- 2024-2027 ; 7M€ EU funding
- Hybrid solar thermal (ST) and photovoltaic (PV) system for industrial heat and power (up to 250 °C) with a **single-media thermocline thermal storage** (TES)
- Construction of a TRL7 prototype in an industrial plant (Spain):
  → ST up to 300 kWth, PV up to 20 kWp, e-TES up to 1 MWh

TES : 15 m³ thermocline tank ; [150;210°C]




**Objective : use biodegradable and non-toxic fluids (such as vegetable oils) as heat transfer and storage fluid.**

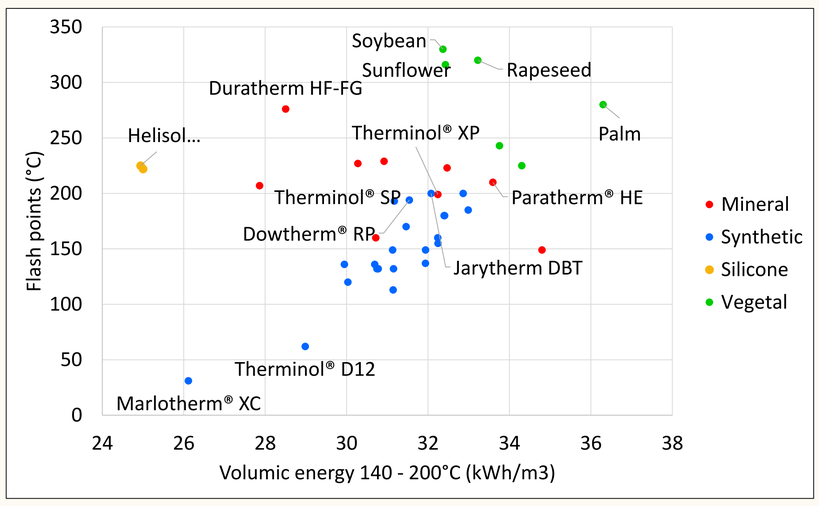
## METHODOLOGY

**Literature review and screening :**
- Commercial HTF : fluid properties and stability, characterization techniques, selection criteria, their use in TES, material compatibility…
- Vegetable oils : properties, normalized characterization techniques, use as HTF, thermal stability and operating conditions
- Commercial HTF screening and comparison with vegetable oils

**Experimental study :**
- Vegetable oil ageing study under specific conditions to address data gaps

## REVIEW AND SCREENING

**Commercial HTFs:**
- Wide range of properties, performance, and cost
- Standardized characterization protocols and regular supplier support in use

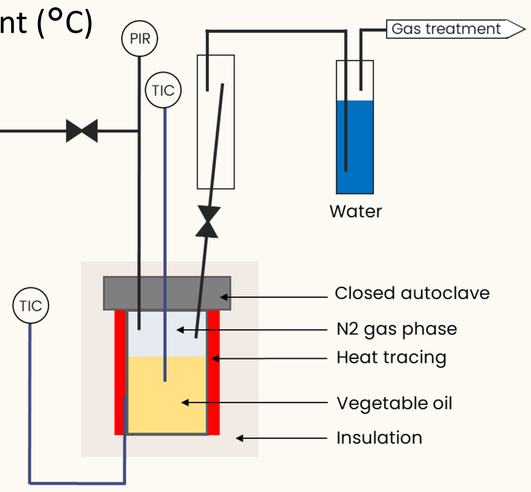



**Vegetable oils:**
- Very interesting properties for unused oil: high flash points and energy densities (*see figure*)
- But lack of knowledge regarding the thermal stability : no accepted standards
- Many results regarding low-T properties (<100 °C) [3][4] and oxidative stability in air at medium T (<200 °C) [5]
- Some results in inert atmosphere [6], including studies on material compatibility (dual-media TES)
- But key data are missing to assess if vegetable oils can be used as HTFs and up to which temperature : experimental study needed

## THERMAL AGEING STUDY OF VEGETABLE OILS

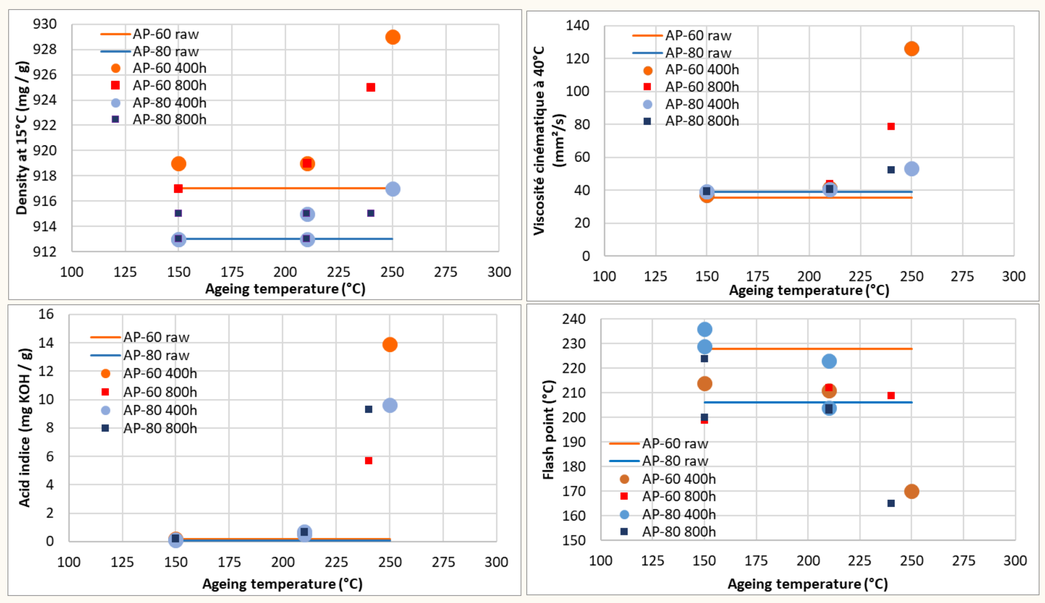
### MATERIAL AND METHODS

- 2 vegetable oils : refined rapeseed and oleic sunflower (AP-80 and AP-60 by Cargill)
- 8 stainless steel autoclaves of 300 mL with 180 mL of oil (20°C)
- Ageing at 150°C ; 210°C ; 240 or 250°C for 400h ; 800h ; 1200h
- Preheating stage before ageing: several ≥4 h plateaus under $N_2$ flow
- Analysis : ρ(T), μ(T), λ(T), cp(T), TG(%), Iodine and Acid Values, %$H_2O$, flash point (°C)




### RESULTS *(study in progress)*

- Thermal stability : refined oleic sunflower > refined rapeseed
- Quite stable until 210°C : small increase of AI but stable properties
- Strong degradation observed from 240°C




## CONCLUSION AND FUTUR WORKS

- Vegetable oils could be interesting HTF in inert conditions, but lack of knowledge regarding their thermal stability, and lack of standards
- Experimental study : quite stable properties up to 210 °C for 800 h, but significant degradation beyond this temperature.

Outlooks:
- Complete this study with 1200 h results and all the analyses (cp, TG)
- Study of gaseous degradation products
- Tests under other conditions (S/V ratio, scale-up, extended durations)
- Material compatibility testing

## REFERENCES

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This project has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No 101136140, project INDHEAP