Institute of Chemical
and Energy Engineering

Bio-oil from Vineyard Residues:

Liquid pyrolysis products (bio-oil) from grapevine pruning, wood and pomace residues – results from the EU VINNY project

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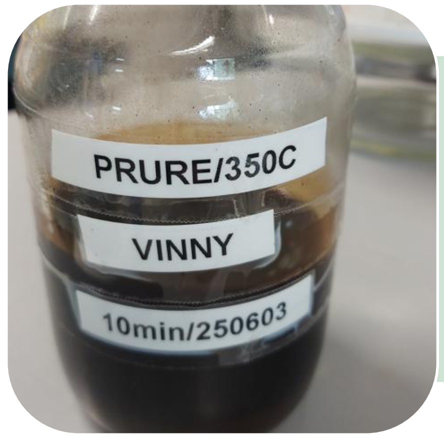
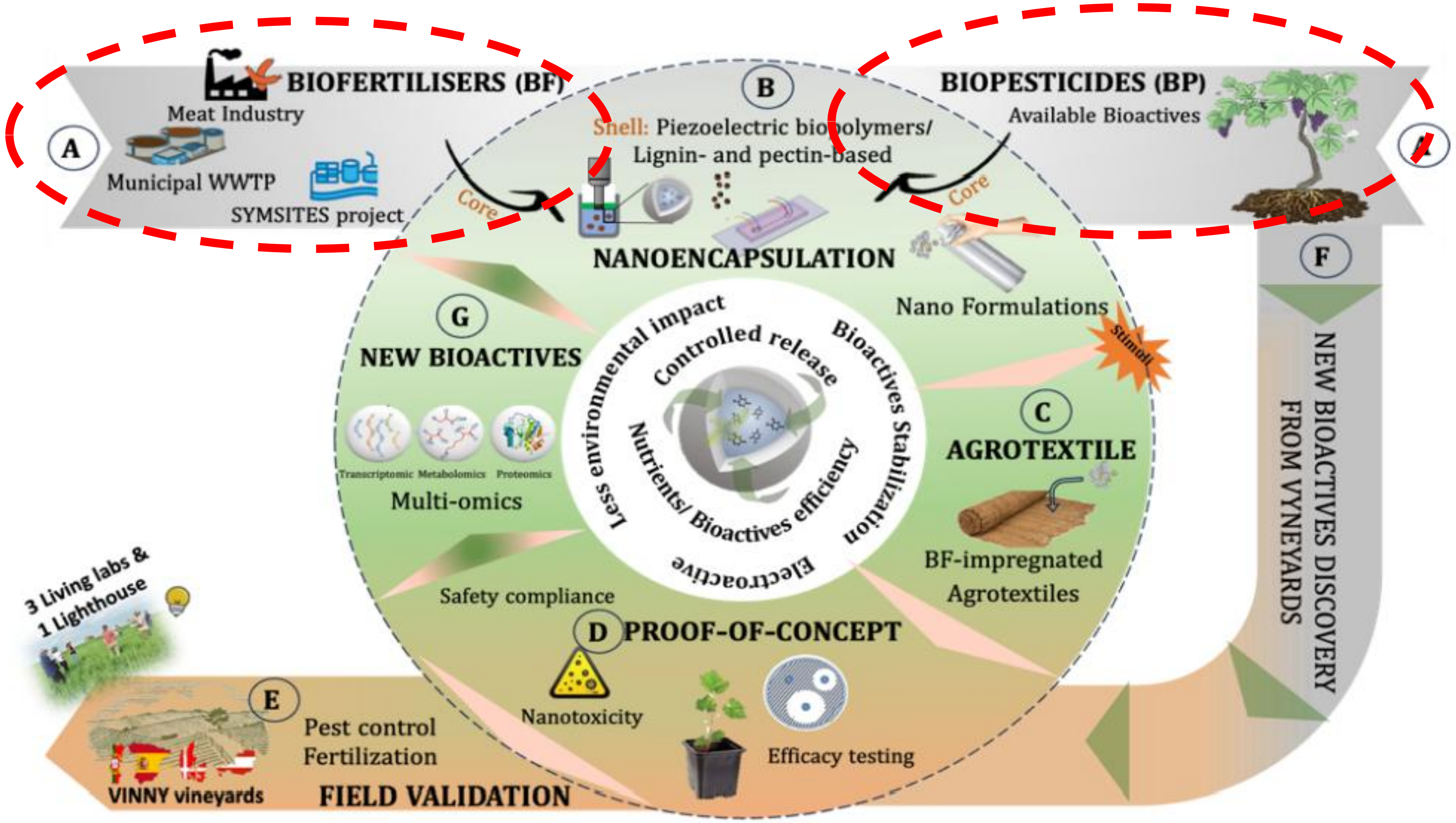
Pyrolysis of Vine Residues: Two Products, Not One

- European Project focused on sustainable viticulture
- Goal: 50% reduction in the use of chemicals in viticulture
- BOKU's part is to provide and optimize the production of bio-oil (tar) and biochar



Tar = Possible Biopesticide

Char = Biofertilizer



Why Look at the Liquid Fraction at All?

- Pyrolysis liquids contain phenolic and acidic compounds with known antifungal, insecticidal and antibacterial activity

- **Published studies on pesticidal pyrolysis liquids show:**
  - Most effective fungicidal liquids: produced between about **440–540 °C**
  - Most effective insecticidal liquids: produced between about **350–550 °C**
  - These ranges line up well with our project's own pyrolysis temperatures (**350, 500, 650 °C**)
  - Almost no chemical post-processing was needed in the literature – the raw condensate is typically used as-is

- **This makes the liquid fraction a low-effort by-product to valorise alongside biochar**

From Vineyard Waste to Lab-Scale Pyrolysis

Three viticultural residue streams pyrolysed in BOKU's lab-scale reactor PYREKA 3.0:

- WORE – wood residues from abolished vines
- PRURE – soft pruning residues
- POMACE – grape pomace (skins, seeds, stalks)
- Pyrolysis temperatures tested:
    - 350, 500, 650 °C (WORE)
    - 350 °C (PRURE, POMACE)

- Condensable vapours collected and quantified via a cold trap → gravimetric tar analysis

WORE – vine wood residues

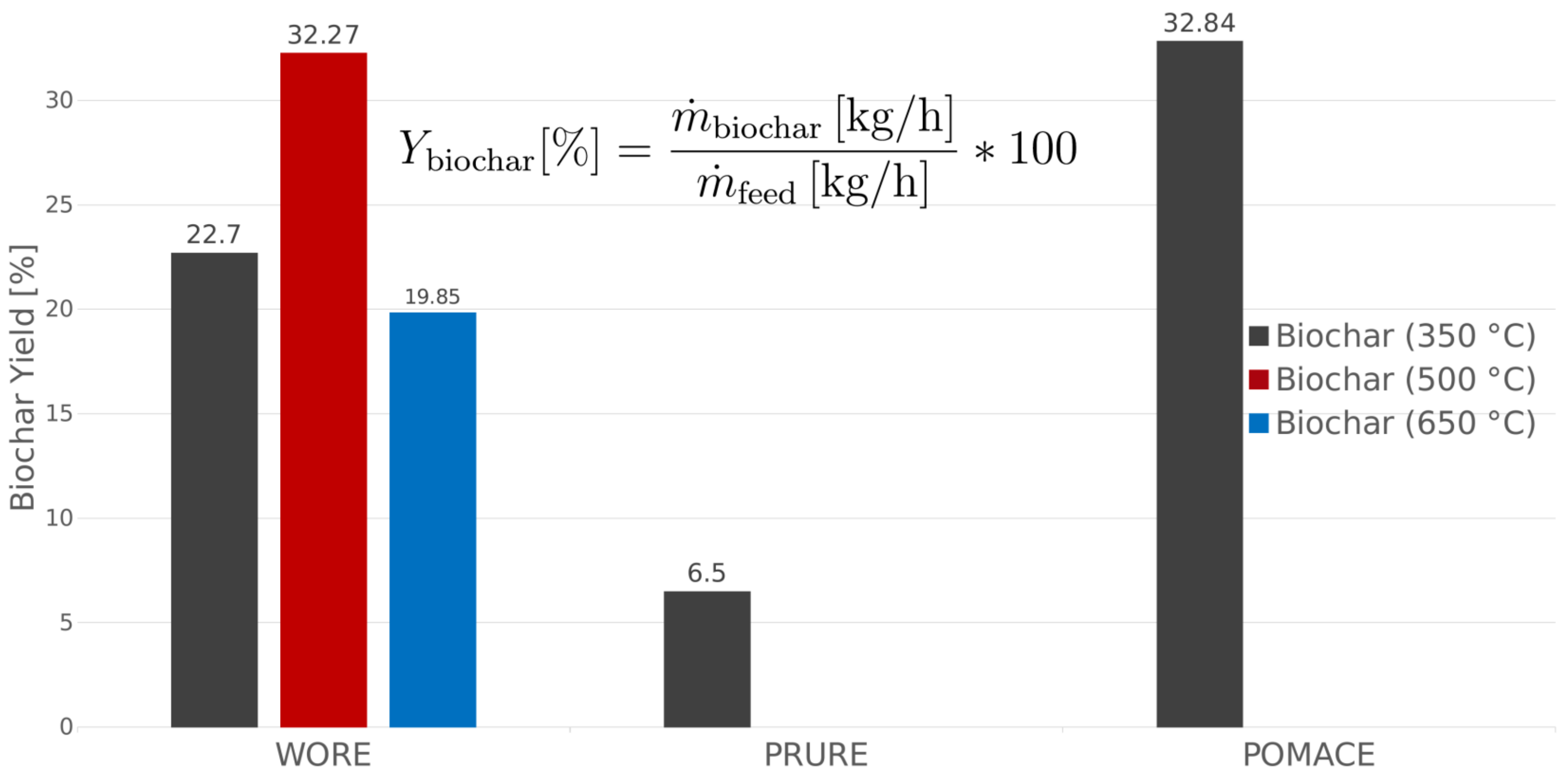
PRURE – soft prunings

POMACE – grape pomace

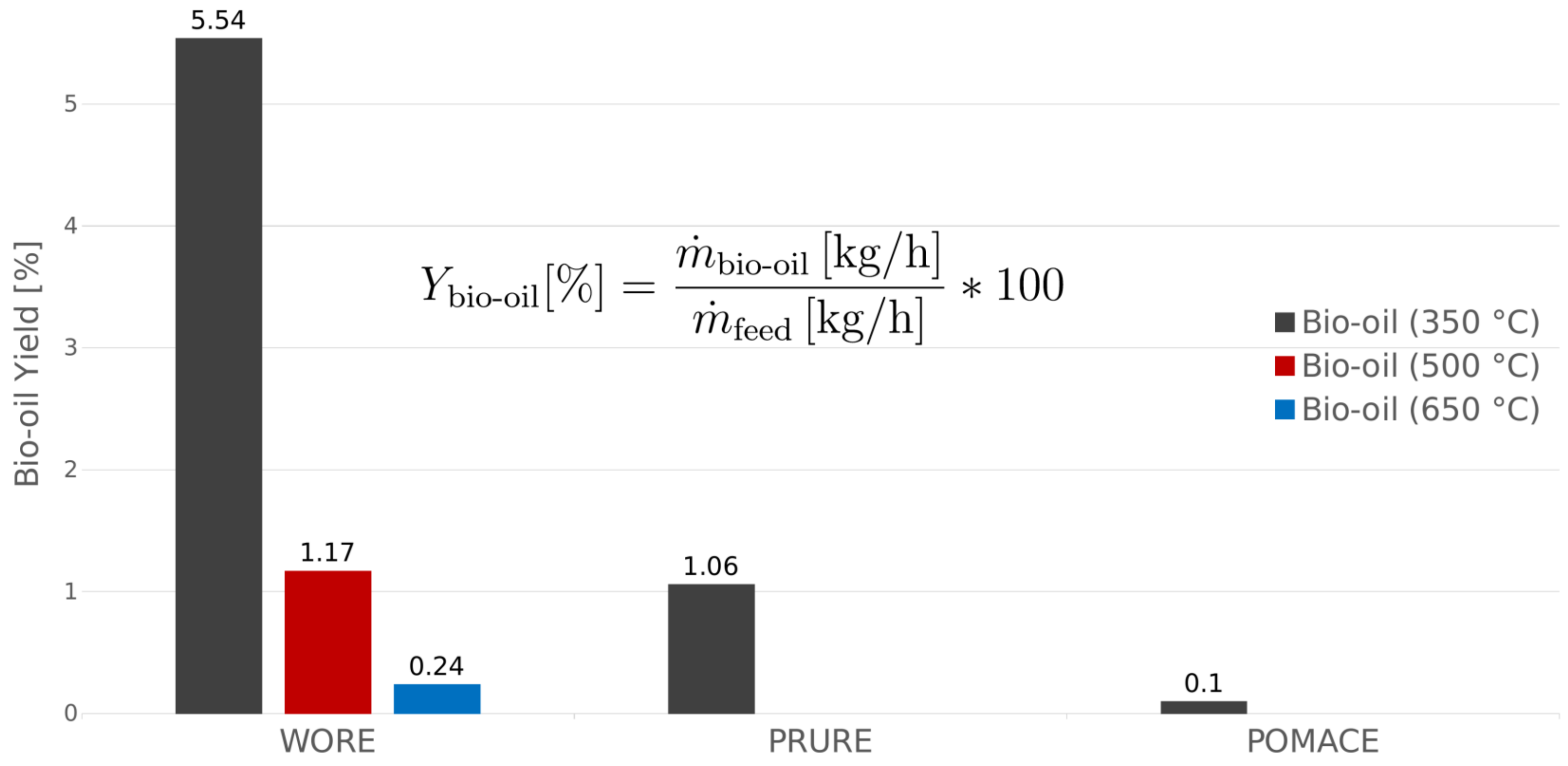
PYREKA 3.0 reactor

Results: Biochar Still Dominates – But Bio-oil Is Not Negligible

Biochar yield by feedstock and temperature:

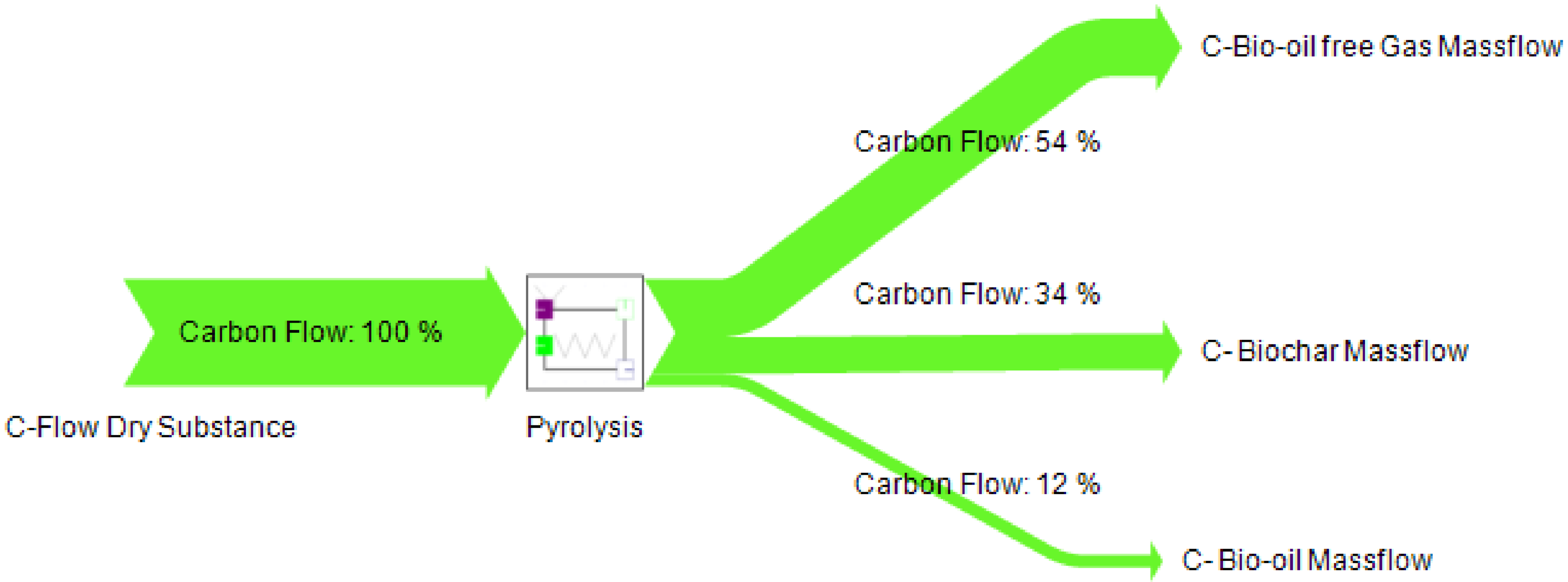


Bio-oil yield by feedstock and temperature:

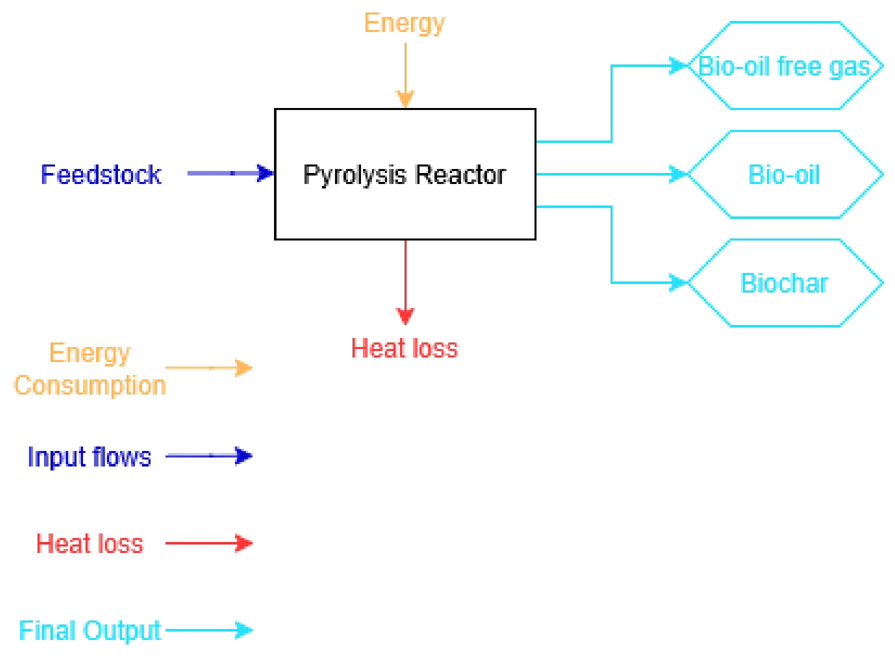


- Highest bio-oil yield: 5.5% for WORE at 350 °C – also the project partners' preferred temperature for pesticidal activity
- Bio-oil yield drops sharply at higher pyrolysis temperatures, while biochar yield peaks around 500 °C

Where Does the Carbon Go? (WORE, 350 °C)



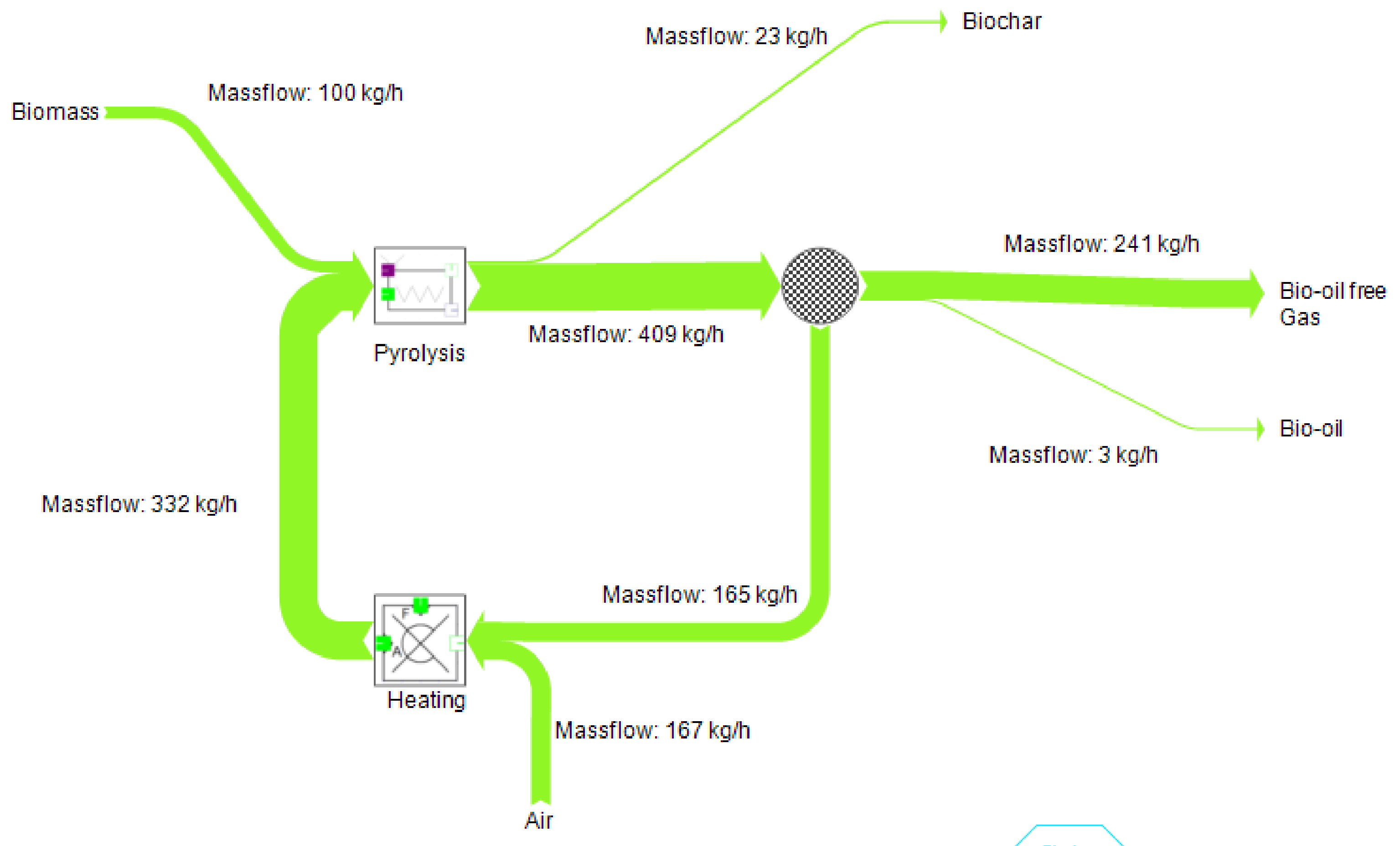
Model Experimental Reactor (Pyreka):



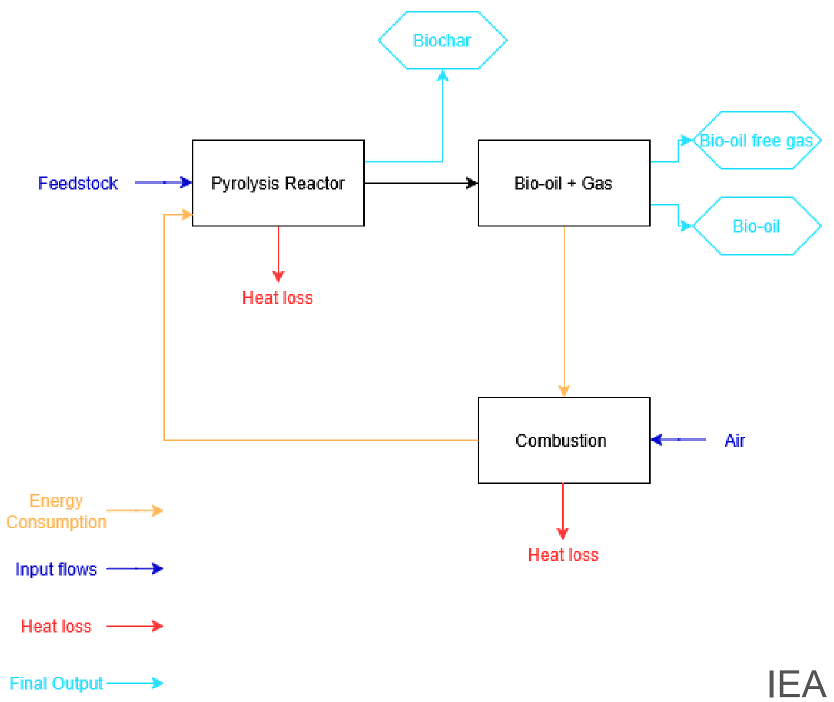
- 34% of the feedstock carbon ends up in the biochar – long-term soil carbon storage
- 12% of the feedstock carbon ends up in the bio-oil – the fraction of interest for bio-pesticide use
- 54% leaves as bio-oil-free gas, usable for process heat

From Lab Bench to Industrial Scale

Simulated mass flows, industrial-scale autothermal reactor (100 kg/h feed, WORE 350 °C)



Industrial Plant Model:



The validated lab-scale model (IPSEpro) was used to simulate a 100 kg/h industrial-scale unit

- An autothermal design is key: part of the pyrolysis gas is combusted to heat the reactor, so no external electricity is needed for heating
- At this scale: 23 kg/h biochar, 241 kg/h bio-oil-free gas, and 3 kg/h bio-oil are obtained
- Trade-off: using gas (and some bio-oil) for heat recovery increases energy efficiency but reduces the recoverable bio-oil fraction – a design choice for future plants

Key Takeaways

- **Pyrolysis of viticultural residues is not a single-product process – biochar and bio-oil are produced together**

- The liquid fraction, usually a low-value by-product, has documented pesticidal potential and could replace part of the chemical inputs used in viticulture

- 350 °C is a practical sweet spot for WORE feedstock: highest bio-oil yield, a reasonable biochar yield, and the temperature favoured for pesticidal activity by project partners

- A validated process simulation now exists, supporting scale-up decisions without further costly experiments for every design variant

- **This positions bio-oil valorisation as a realistic, low-cost addition to existing biochar production at pyrolysis plants**