# POMEVAL

## Conversion of POME into valuable products

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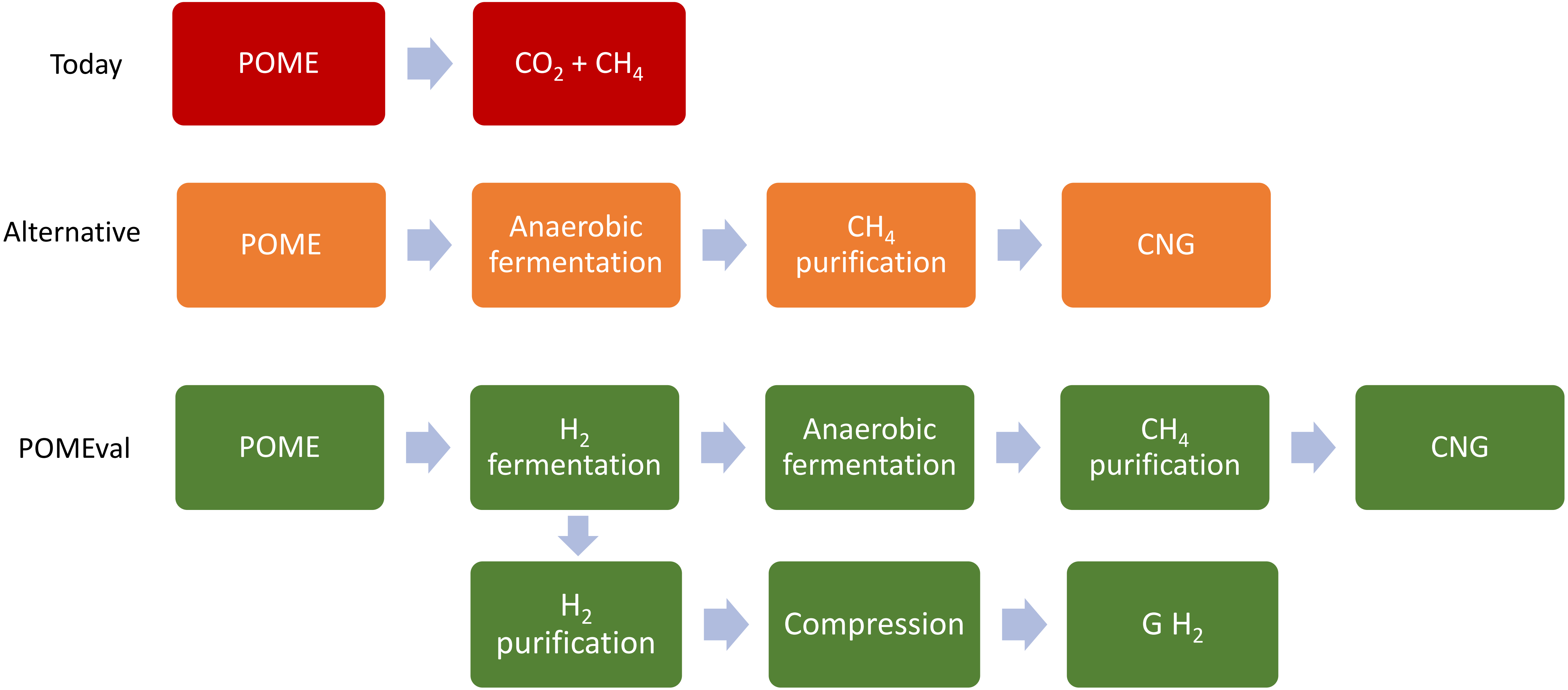
# Problem to solve

- Many palm mills have high greenhouse gas emissions
- POME (Palm Oil Mill Effluent) is fermented in open air
- The consortium analysed the possibility to convert POME into valuable products

# Consortium

| Person involved | Affiliation | Expertise | Location |
|---|---|---|---|
| **Pieternel Claassen and Johan van Groenestijn** | Wageningen Food & Biobased Research | Hydrogen fermentation and anaerobic digestion | NL |
| **Frank Bergmans** | MVO The Dutch Association for Oils and Fats Industry | Fatty acids from POME | NL |
| **Francois Huberts** | DMT Environmental Technology | Biogas upgrading, water treatment | NL |
| **Ellart de Wit** | HyGear | Hydrogen recovery and purification, industrial gas handling | NL and Singapore |
| **Rob van As** | Paques | Bioreactor design, biological waste water treatment | Malaysia and NL |
| **Jasmine Hue** | Embassy of the Kingdom of the Netherlands | Water and waste management | Malaysia |
| **Jamaliah Jahim and Peer Mohamed** | National University of Malaysia | Hydrogen fermentation of POME followed by anaerobic digestion | Malaysia |

# Process Flow Diagram

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# POMEval products

- Typical palm mill
  - Fresh fruit bunch: 60 ton/h
  - POME: 750 $m^3$/day
- Possible products

| Product | Amount (tonnes/year) |
|---|---:|
| Hydrogen gas | 43 |
| Methane as CNG | 1820 |
| Carbon dioxide compressed | 2925 |
| Sludge-oil | 2573 |
| Fertilizer in treated effluent | 156 |

Sludge-oil and fertilizer are valorized today

# Technical background

## $H_2$ fermentation has two functions:

1. Pre-treatment of effluent to increase yield and productivity anaerobic fermentation
   - Smaller anaerobic fermentor, higher throughput
     Lower CAPEX
     Lower OPEX
2. Produce $H_2$
   - $H_2$ as chemical/fuel


Test unit used in Malaysia

# Valorization CNG & $H_2$

- $H_2$ and $CH_4$ need at palm oil mill is low
- Produce sellable product that can be transported to customer

- $H_2$ Market
  - Industrial use (chemical, glass, metal industries)
  - Fuel for hydrogen cars
- Purify and delivery at 300 bar
  - Includes filling hub

- CNG market
  - As fuel for hydrogen cars
  - Cooking/Heating
- Purify and delivery at 200bar
  - Includes filling hub

# CNG business case

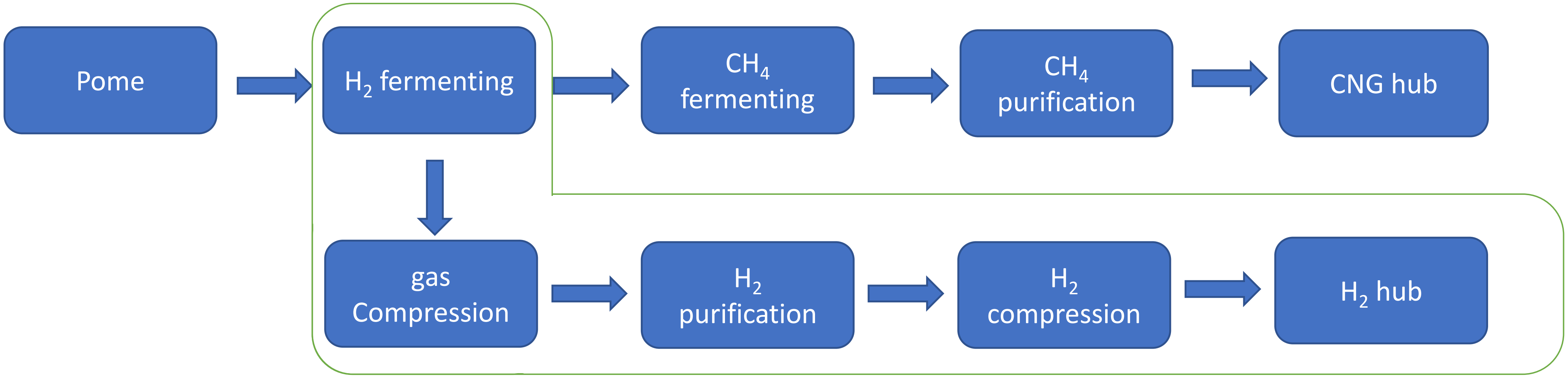
- CNG costs mainly by depreciation of CAPEX
  - Digester (€ 405,000 / a)
  - Biogas-upgrading (€ 240,000 / a)

- Total CNG costs € 0.35 / kg CNG

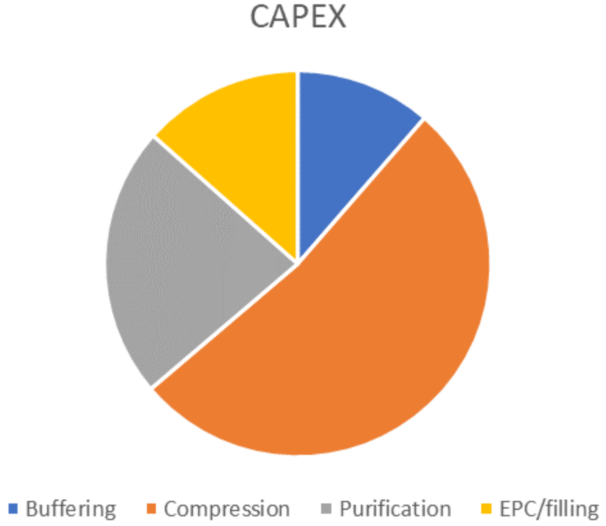
- Market price: € 0.37 / kg CNG

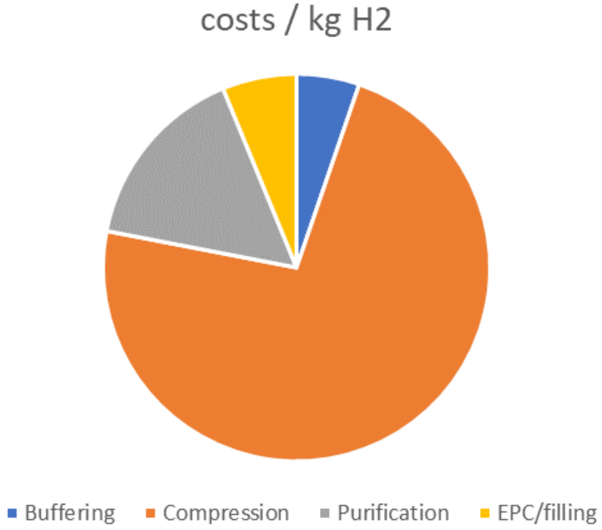
- Yearly revenue € 673,000
  - 1820 tonnes / a

# Valorization $H_2$ fermentation/purification




- Compression costs are main cost driver
- Total $H_2$ costs: €7.52 / kg $H_2$



# $H_2$ business case

- Production costs central SMR with natural gas
  - €1,50-2,00 / kg $H_2$ (excluding depreciation)
  - Compression and handling €1,00 – 1,50 / kg $H_2$
  - Production costs Grey hydrogen: €2,50-3,50 / kg $H_2$ (excluding trucking)

- Additional value of Green Hydrogen
  - Expected to be around €1,00 / kg $H_2$

- Future merchant price green $H_2$: €3.50-4.50 / kg $H_2$
  - depending on value of "green"

- Yearly revenue € 168,000

# Commercial analysis of solution

- CNG has positive (marginal) business case (5,4% marge)
  - CNG reactor based upon increased yield and activity of $H_2$ fermention
- $H_2$ fermentation no business case today
- Need other sources of valorization
  - $CO_2$
    - Needs additional investements and market
  - Commercialization becomes very complex

| Product | Amount (tonnes/year) | Value (€/tonne) | Annual benefit (€/year) |
|---|---|---|---|
| Hydrogen gas | 43 | 3500-4500 | 168,000 |
| Methane as CNG | 1820 | 370 | 673,000 |
| Carbon dioxide compressed | 2925 | 120-170 | 424,000 |

# Discussion

- Costs of products are in ball-park of feasibility
  - Improvements possible ($H_2$ fermentation, anaerobic fermentation, CNG upgrading, $H_2$ compression/purification)

- Focus in world on reducing green house gas emissions will open markets for CNG and $H_2$
  - In (near) future green hydrogen demand for mobility will increase
  - Potentially allows higher $H_2$ prices
  - Penalties for fossil based feedstock

# Next steps

- Reduce complexity of commercialization / Proof of principle
- R&D on improving bottle necks
  - Improve $H_2$ fermentation
    - Yield
    - $H_2$ concentration in gas
  - Improve hydrogen purification / compression
  - Reduce CAPEX of CNG
- Pilot of combined system (TRL6/7)
- Demonstration of combined system (TRL8)
- Commercial launch (TRL9)

# Next project

- Consortium has been built on technology providers
  - Requires end-customer for piloting/commercialisation

- Next project (Reach TRL6/7)
  - Make detailed PFD
    - Use assumption – best engineering knowledge
  - Do laboratory test on modules
    - Input into optimize PFD
    - Calculate cost options
  - Optimize PFD on economics
  - LCA
  - Prepare for demonstration

# Funding options

- R&D
  - RTD-funds
    - Horizon2020
    - Malaysia University funds
    - RVO
  - Co-funding by industry

- Piloting
    - MOSTI : Malaysia Ministry for science, technology and industry
      ICF: International Collaboration Fund
    - Malaysia biomass organization: Enhancing circularities of Malaysia Agriculture sector
    - Water And Energy For Food:a Grand Challenge For Development
      WE4FAsiaBids@tetratech.com
    - Co-funding by industry / end-user

# Thank you for your attention


Keep In Touch
With Us

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# Development objectives

- Optimization of $H_2$ productivity and yield
  - various process- and reactor configurations.
  - H2 yield/sugar maximized and higher percentage in the raw gas (UKM, WFBR)

- Determination of the effect of $H_2$ fermentation on improved anaerobic digestion
  - Optimization, extent, cause of the effect (UKM, WFBR)

- Improvement of H2 purification and compression
  - Ionic liquid compression
  - Electro-chemical compression
  - Membrane/VSA coupling
  - Electro-chemical purification

- Reducing CAPEX and OPEX
  - Optimized reactor and process design and smart connection (reuse of wastes): (Paques, DMT and HyGear)

- Demonstrate valorization of products
  - hydrogen, methane, CO2 and sludge oil utilization (Paques, DMT and HyGear)
  - Update and fine-tune of economic assessment including markets and prices

- Proof environmental benefits
  - Identification and quantification of GHG reduction and increase of circularity (UKM, WFBR, Paques, HyGear and MVO)