Increasing Energy Efficiency in Breweries with Gas Turbine Cogeneration

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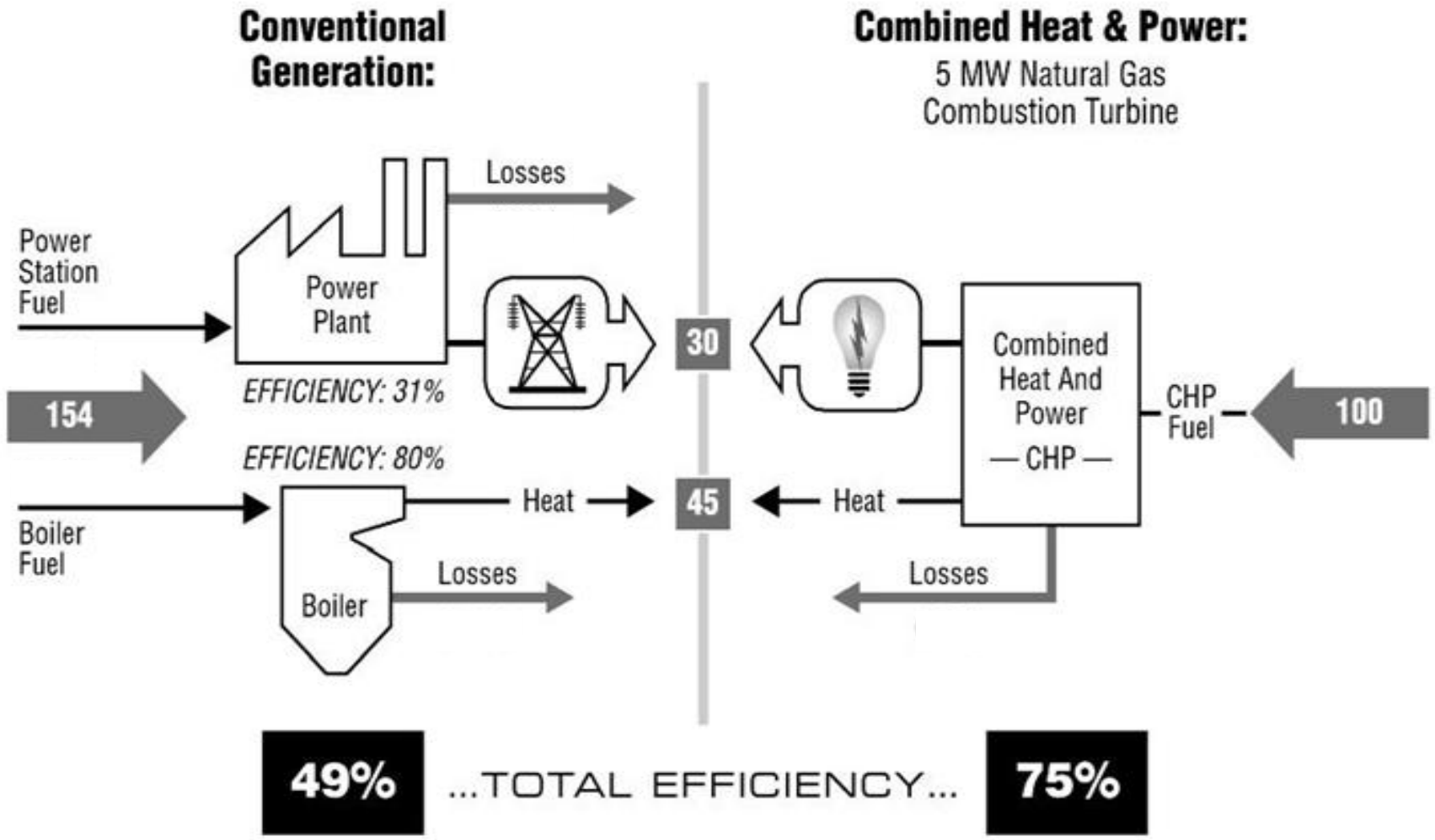
Combined Heat and Power (CHP) increases efficiency



Source: U.S. EPA: Combined Heat and Power Partnership

Combined Heat and Power: Key Benefits

Why OP16 and CHP?

- Reduce production costs
- **Reduce energy costs**
- Convert waste into energy
- **Increase in profits**

- Increase productivity
- Innovative and cheap energy
- Energy efficiency at site
- Potential to control energy prices through CHP
- Energy security→ **Independent energy generation**
- Packaged and simple solution
- **Reliable** power generation

- **Economic support**
- Subsidies for Cogeneration projects
- Reduce emissions

Independency, Reliability, Availability & Profitability

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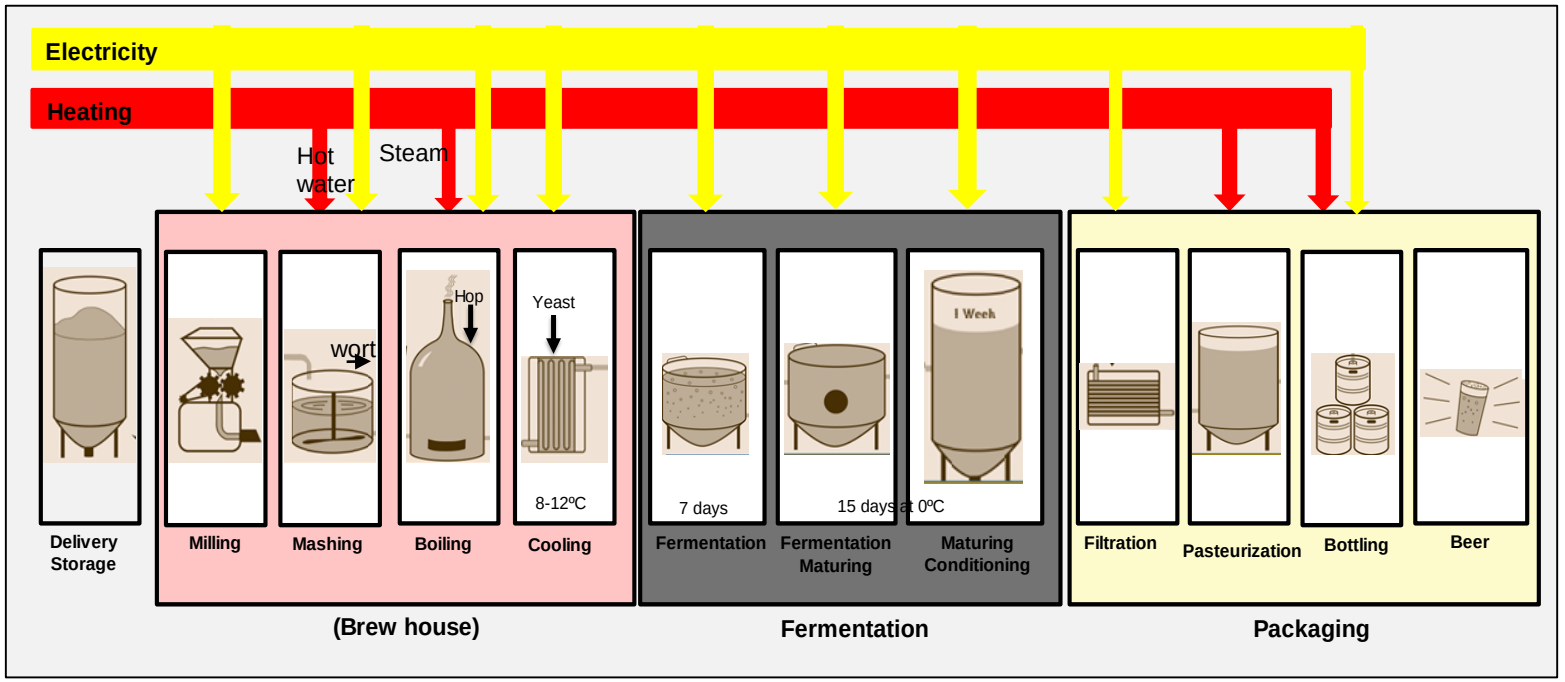
Breweries: Introduction

- Beer: Produced through fermentation of barley or wheat
- Energy intensive process
- Energy accounts for 3-8% of beer production costs
- Emphasis on environmental impact
  - Energy saving technologies (CHP)
  - Waste water treatment

Breweries: Manufacturing Process



Malting
- Malt is weighted, cleaned, stored
- Malt is milled and treated

Mash tank
- Malt and adjuncts mixed in hot water
- Insoluble grains are separated
- Water is drained, wort is obtained

Boiling
- Wort is boiled with hops
- Wort is cooled to 8-20 C, strained, filtered

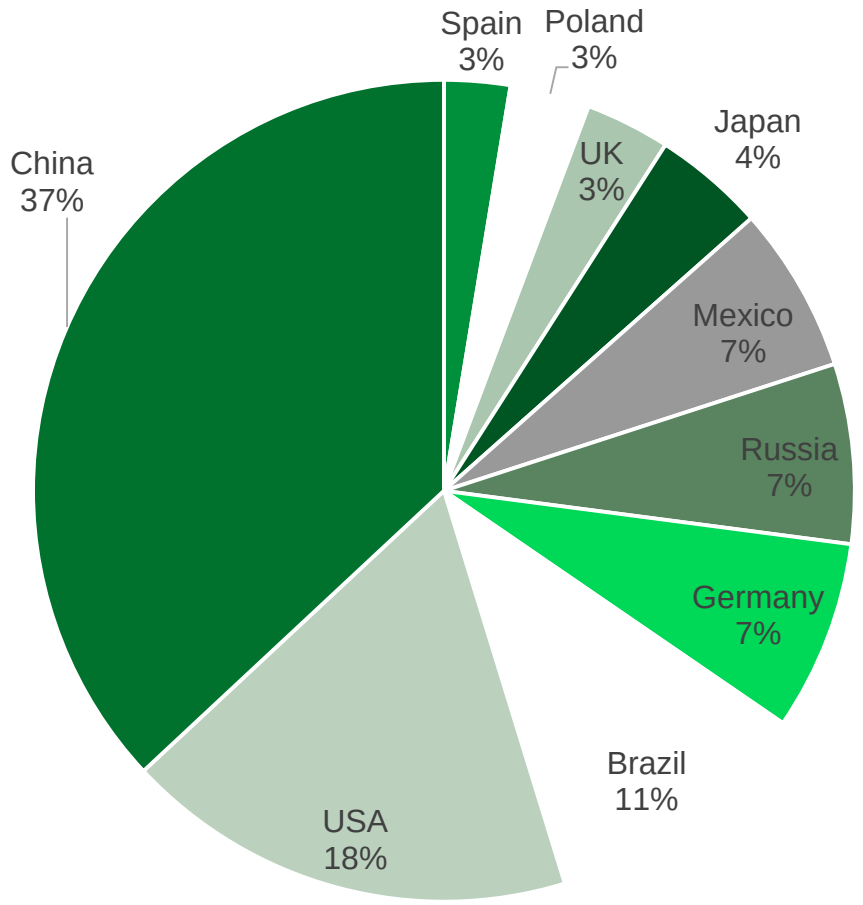
Fermen-tation
- Yeast is added to the cold wort
- Beer is “maturated” and stored

Filtration
- Beer contains yeast and bacteria
- Pumped to the bright beer tank

Packing and CIP
- The beer is bottled and carbonated
- Equipment is deeply cleaned (CIP)

Breweries: Market Distribution

- Worldwide production 200 Billion liters per year
- China is the leader in the production, followed by USA
- Germany production leader in Europe
- Both microbreweries and major breweries present in each country

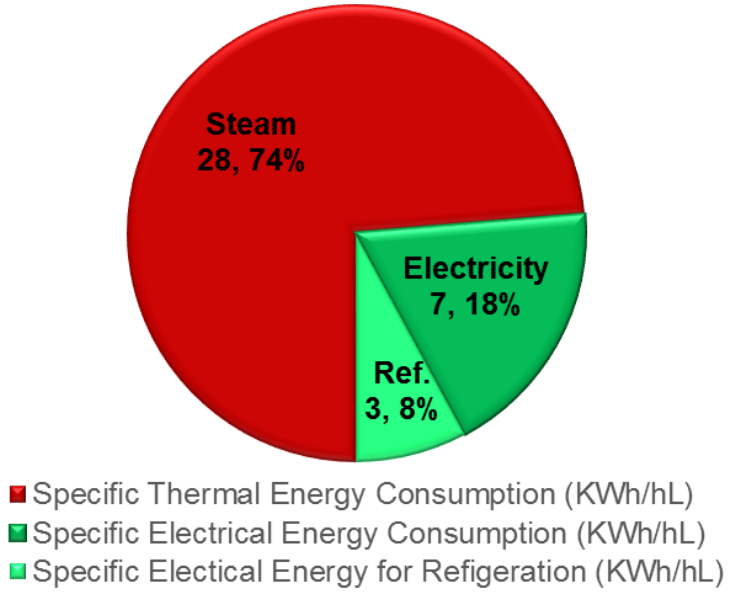


Breweries: Energy Distribution

- Specific Energy Consumption:
  - Amount of energy required to produce 1hL of beer
- Heat to Power ratio favorable for Combined Heat & Power

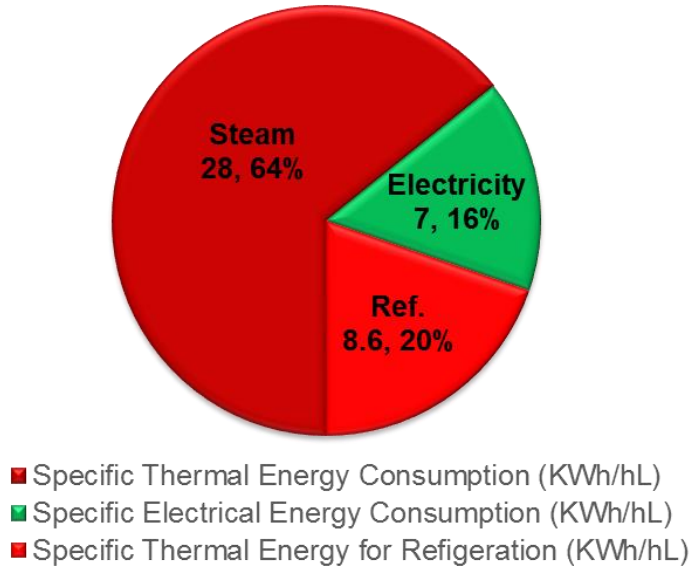
Utilities	Energy level
Hot Water	70-80°C [158-176°F]
Steam	Low Pressure Saturated Steam 5-20 bar [70-290 PSI]

Cogeneration (Electrical Chillers)



Heat to Power Ratio=2.8:1

Trigeneration (Absorption Chillers)



Heat to Power Ratio=5.2:1

*Assuming COP=4 for electric chillers
*Assuming COP=1.4 for absorption chillers

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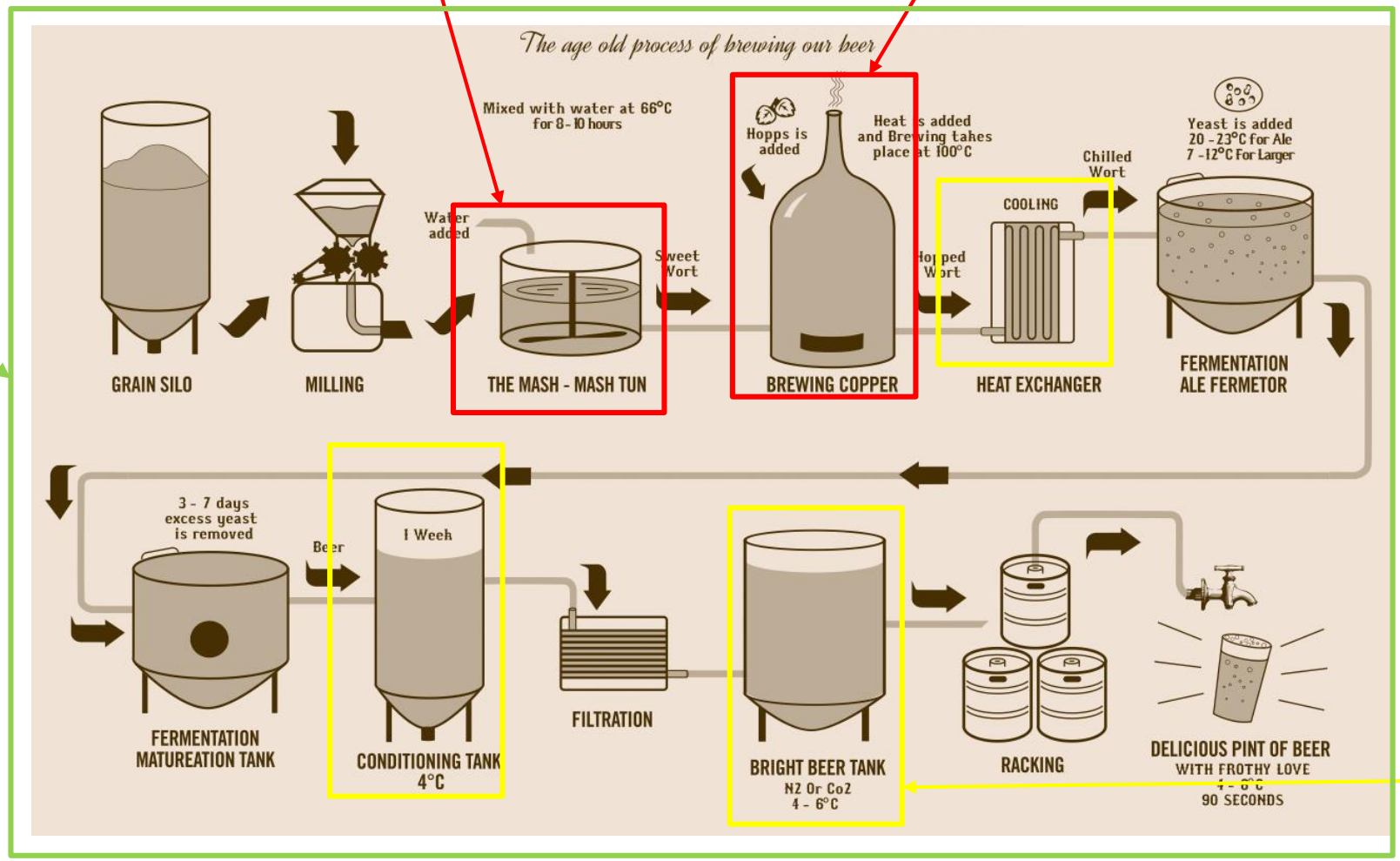
Breweries: Energy Consumption

Hot water

Heat

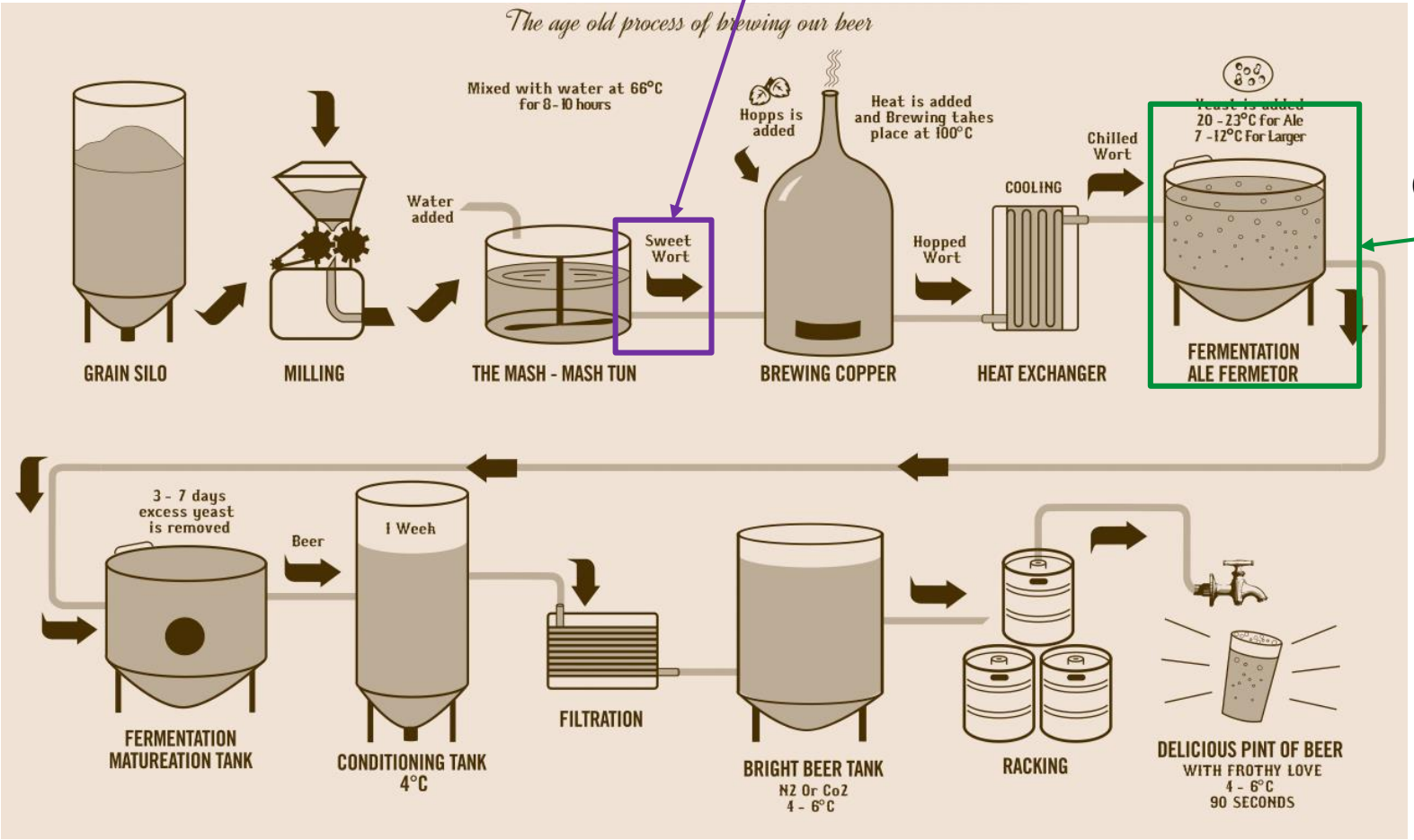
Electricity



Chiller

Breweries: Waste to Power

Grains disposal &
waste water

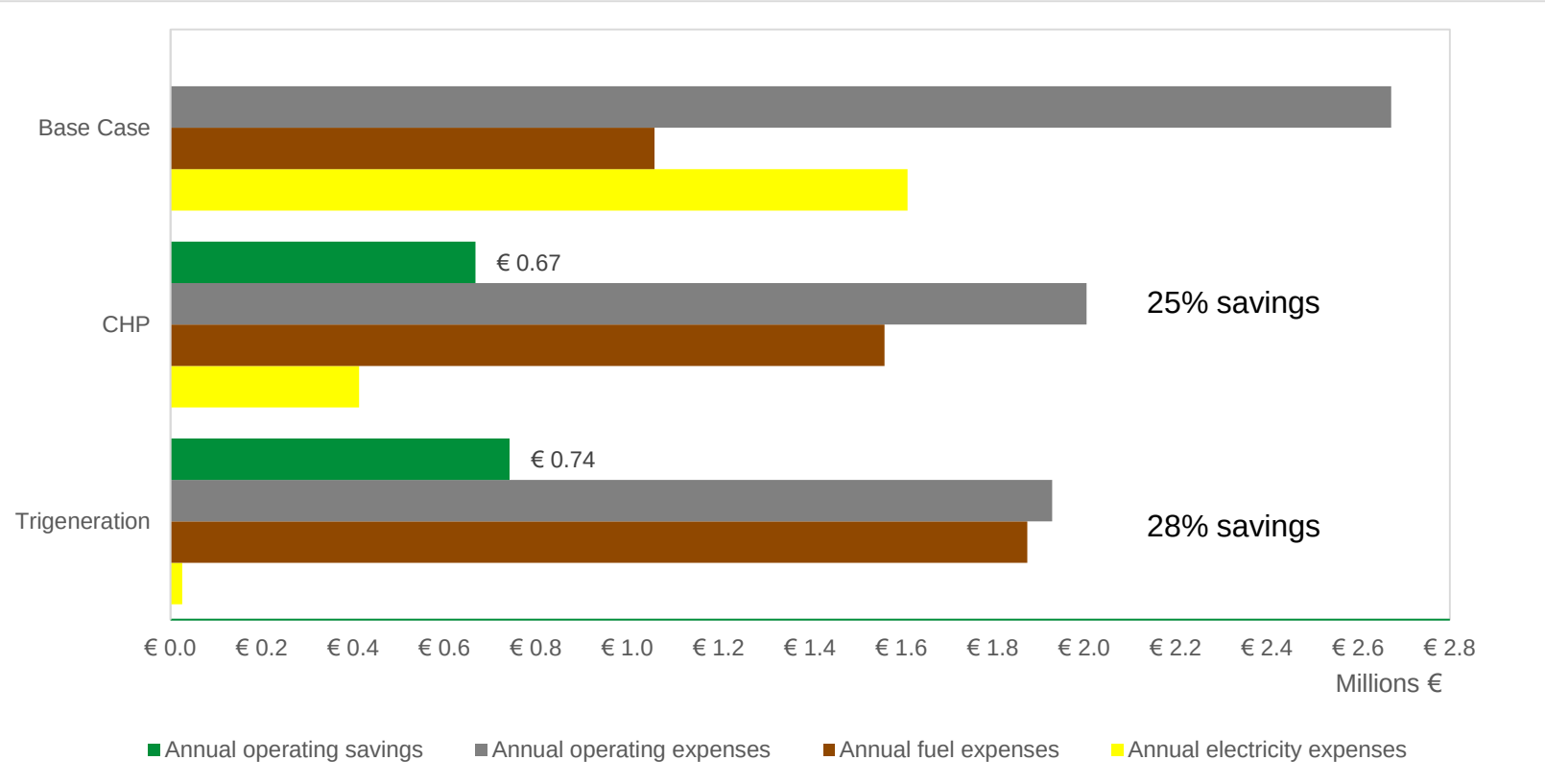


CO2 Recovery plant

Breweries: Energy Consumers

- High thermal energy consumption:
  - Brewhouse
- High electricity consumption:
  - Chillers
  - Compressed air
  - Auxiliary Drives
- Anaerobic wastewater treatment
  - Biogas (Siloxanes & H2S)
- Gasification
  - Spent grains gasification
  - Syngas for OP16 gas turbines

Breweries: Feasibility Study (European Market)



Brewery Size	1.3 million hL
Electricity Demand	2,500 kWe
OP16 Exhaust Heat	4,500 kWth
Chiller capacity	640 RTons
Sat. Steam production	6 tph [13,227 lb/hr] @12bar [174 Psia]
Natural Gas Price	0.028 €/kWh
Electricity Price	0.084 €/kWh

- ✓ **High Operational Savings: >25%**
- ✓ **Quick payback:**
  - ✓ **3.6 years (Trigeneraion)**
  - ✓ **3.2 years (CHP)**

*Trigeneration calculations are including the investment cost of absorption chiller.
** All calculations for Cogeneration and Trigeneration includes complete turnkey costs i.e. CAPEX and OPEX.

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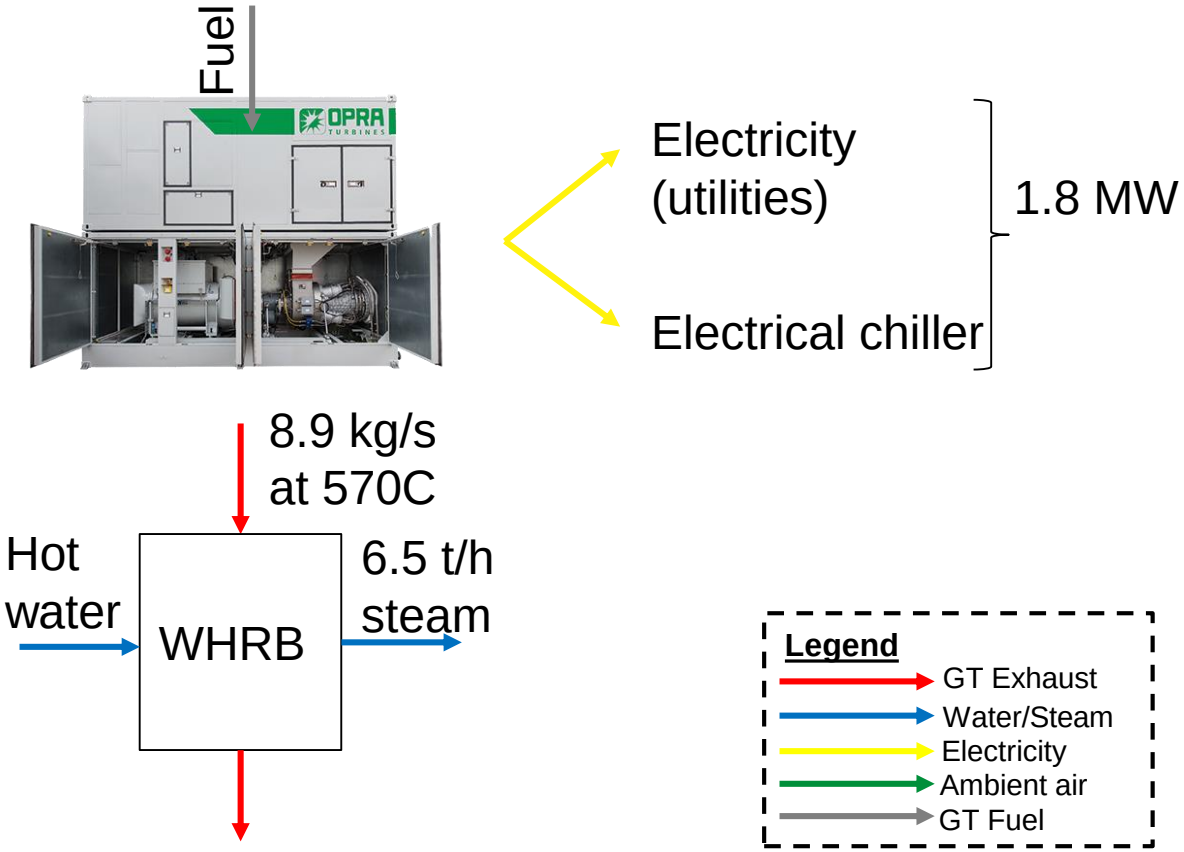
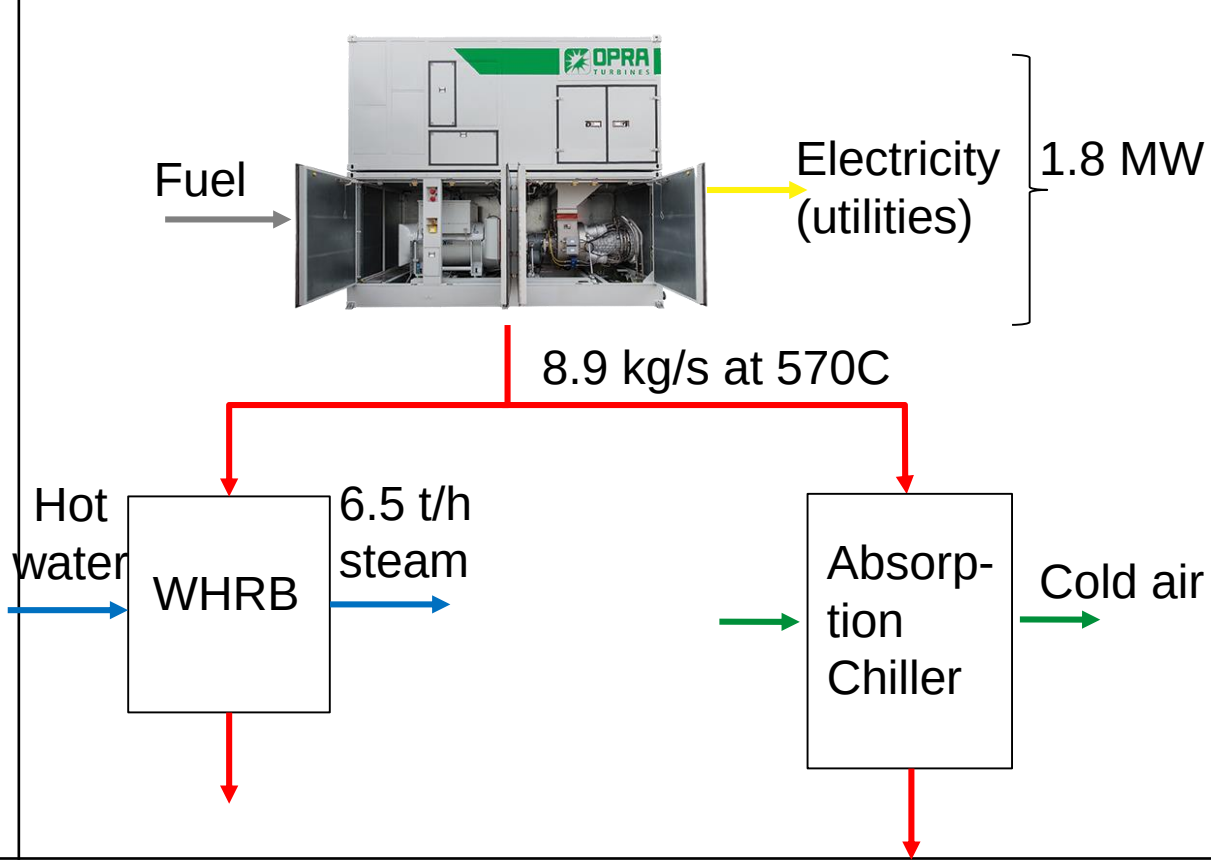
Cogeneration & Trigeneration Integration in Breweries

Cogeneration

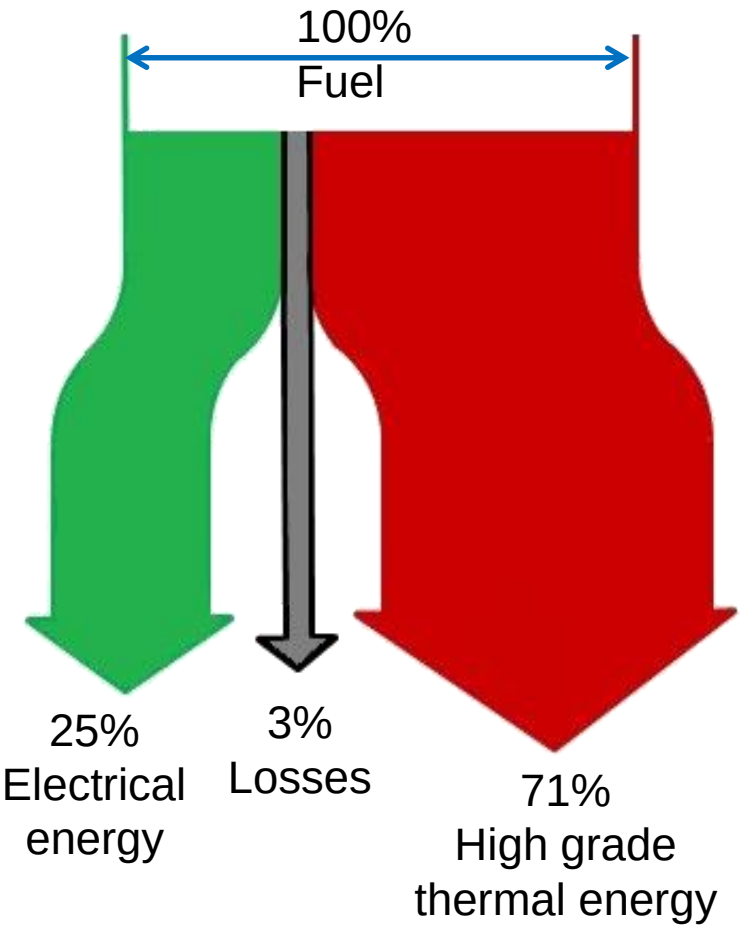


Trigeneration

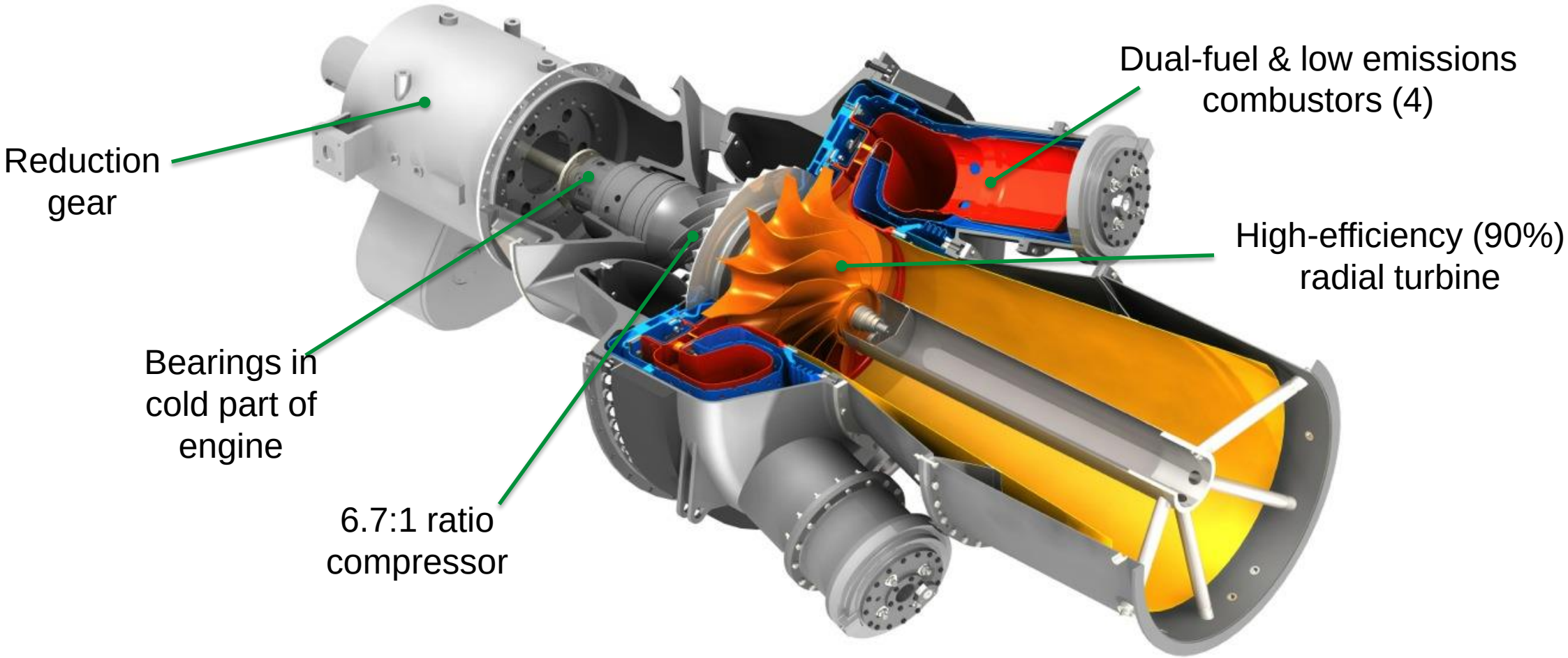


Gas Turbines: Unique points

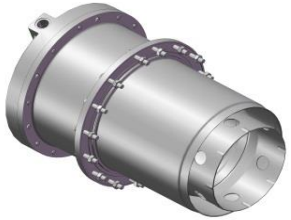
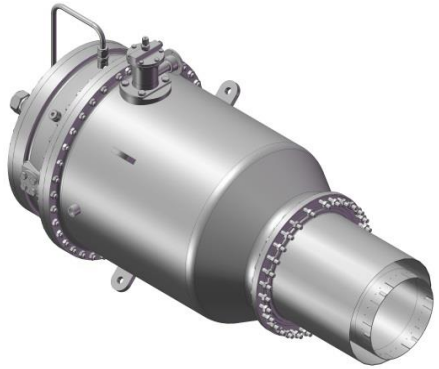
- High heat to power ratio (~3:1): OP16 generates 1,876 kWe with 4,500 kWth
- Utilization of **hot and clean exhaust**:
  - High pressure and temperature steam production for brewhouse
  - Drying of spent grains
  - Operation of absoprtion chillers
- **High** combined **efficiency** (~90%)
- **Continuous** and **reliable** power and heat
- **Low emissions** of OP16 turbines
- **Fuel Flexibility**: multiple fuel use
  - Biogas from waste water treatment
  - Syngas from spent grains gasification
- Compact and Modular: Easy integration into existing process

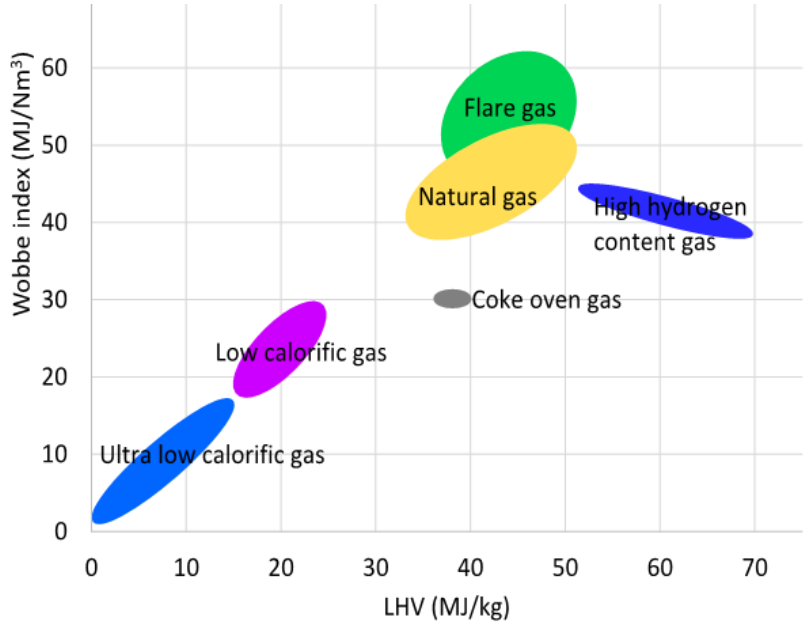


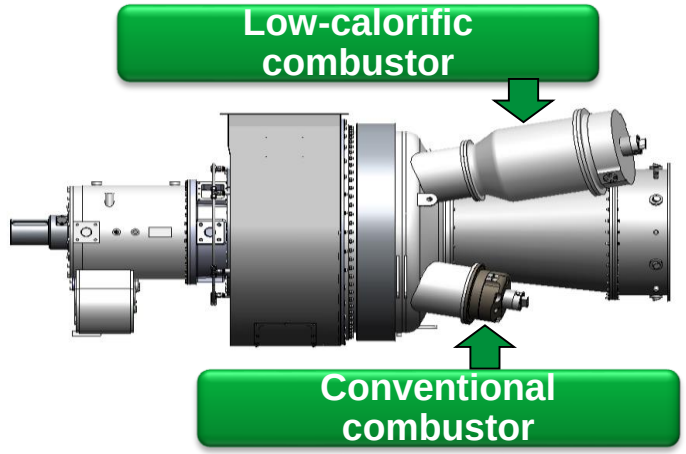
Introduction: OPRA Turbines



Introduction: Combustion Technology

OP16-3A	OP16-3B	OP16-3C
▪ Conventional diffusion type combustor ▪ Gaseous and liquid fuels between 20-70 MJ/kg ▪ Dual fuel operation	▪ Dry low emission combustor ▪ Gaseous fuels between 30-51 MJ/kg ▪ Diesel as back-up fuel	▪ Advanced diffusion type combustor ▪ Gaseous and fuels between 5-25 MJ/kg ▪ High calorific fuel as back-up
		





Thank You

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