RESONANCE STIRLING ENGINE: CHP for SMALL (RESIDENTIAL) BUILDINGS

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INTRODUCTION:

- STIRLING ENGINES for Combined Heat and Power (CHP)

RESONANCE FREE - PISTON SYSTEMS

- OPERATING PRINCIPLE
- RESONANCE MASSES
- OPERATING – CHARACTERISTICS

COMPARISON WITH CONVENTIONAL ARRANGEMENTS

ECONOMICS

- ENERGY- SAVINGS
- EXPECTED ADVANTAGES

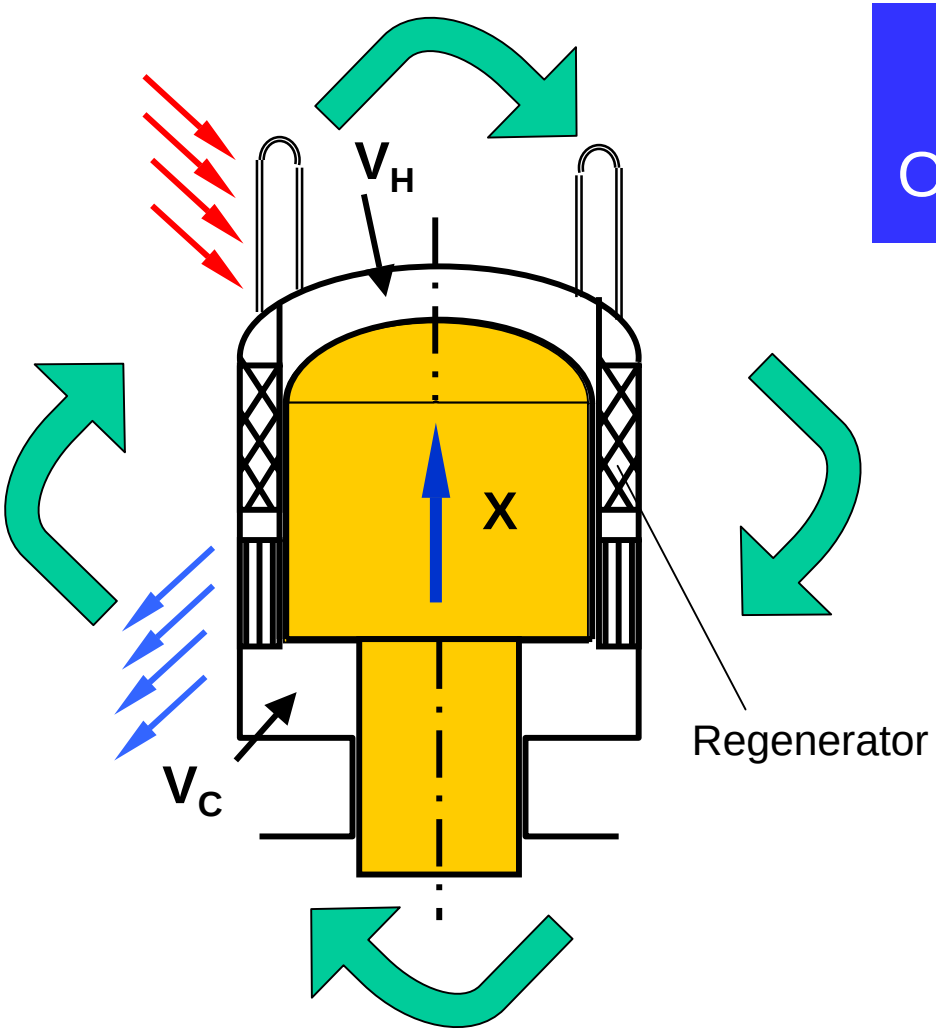
CONCLUSIONS

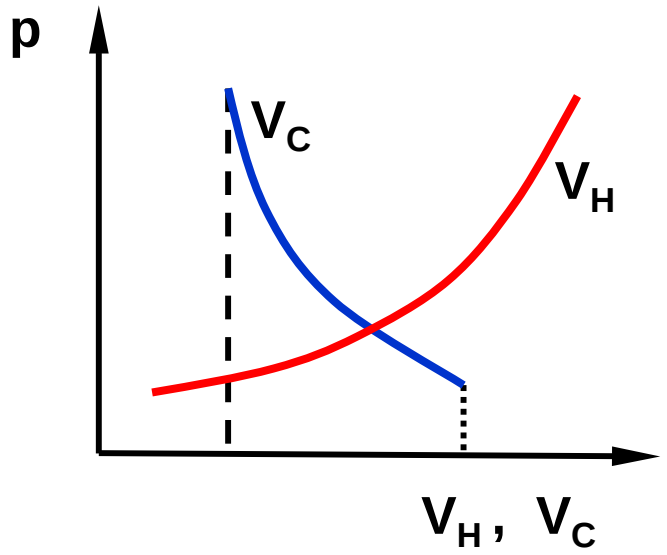
CHP : COMBINED HEAT AND POWER

- Electicity produced at the site of its use
- Engine heat release entirely applied for heating purposes
- Flexible Engine operation according to heating needs
- Small units replacing existing heating devices
  - → reliable, long lasting, maintenance-free service
  - → simple, mass produced units

→ new concept of a free-piston CHP-unit

STIRLING ENGINE OPERATING PRINCIPLE

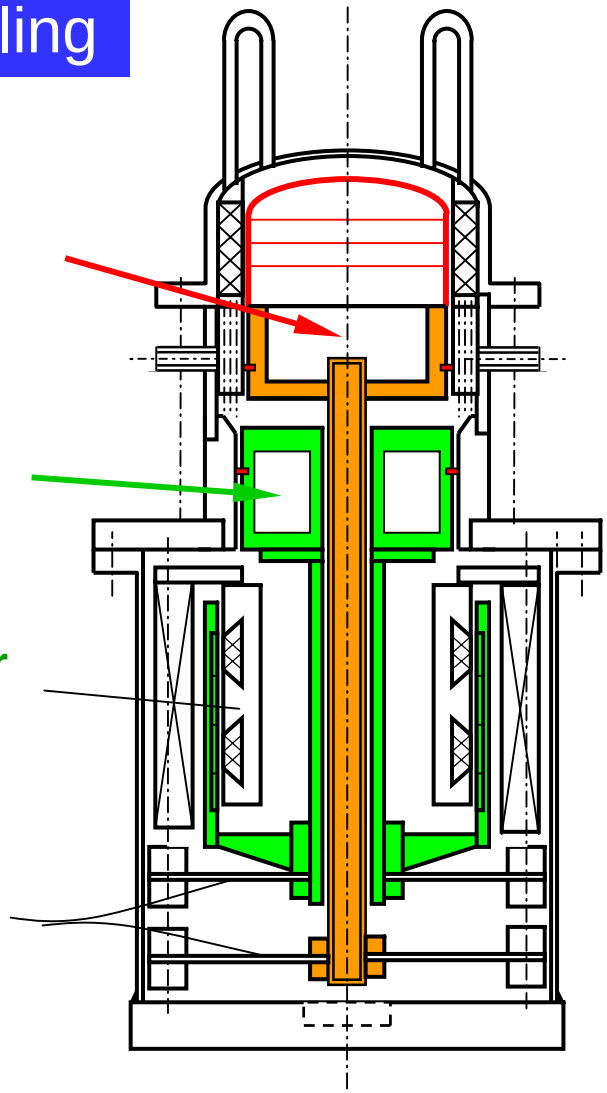




COMPRESS → HEAT

→ EXPAND → COOL

Conventional Free Piston Stirling

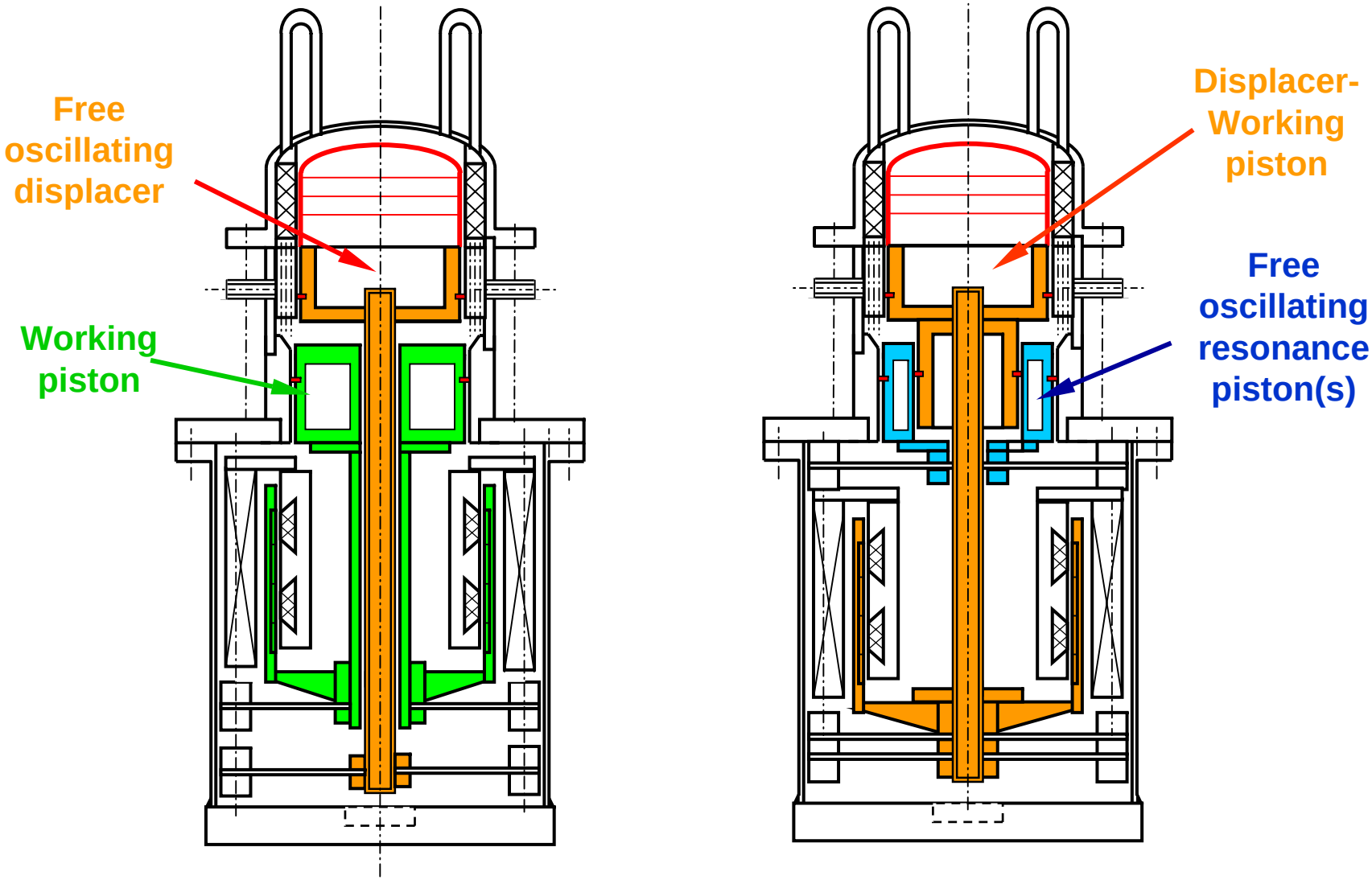


Pressure variation caused by important temperature differences

Pressure variation caused by change of working volume

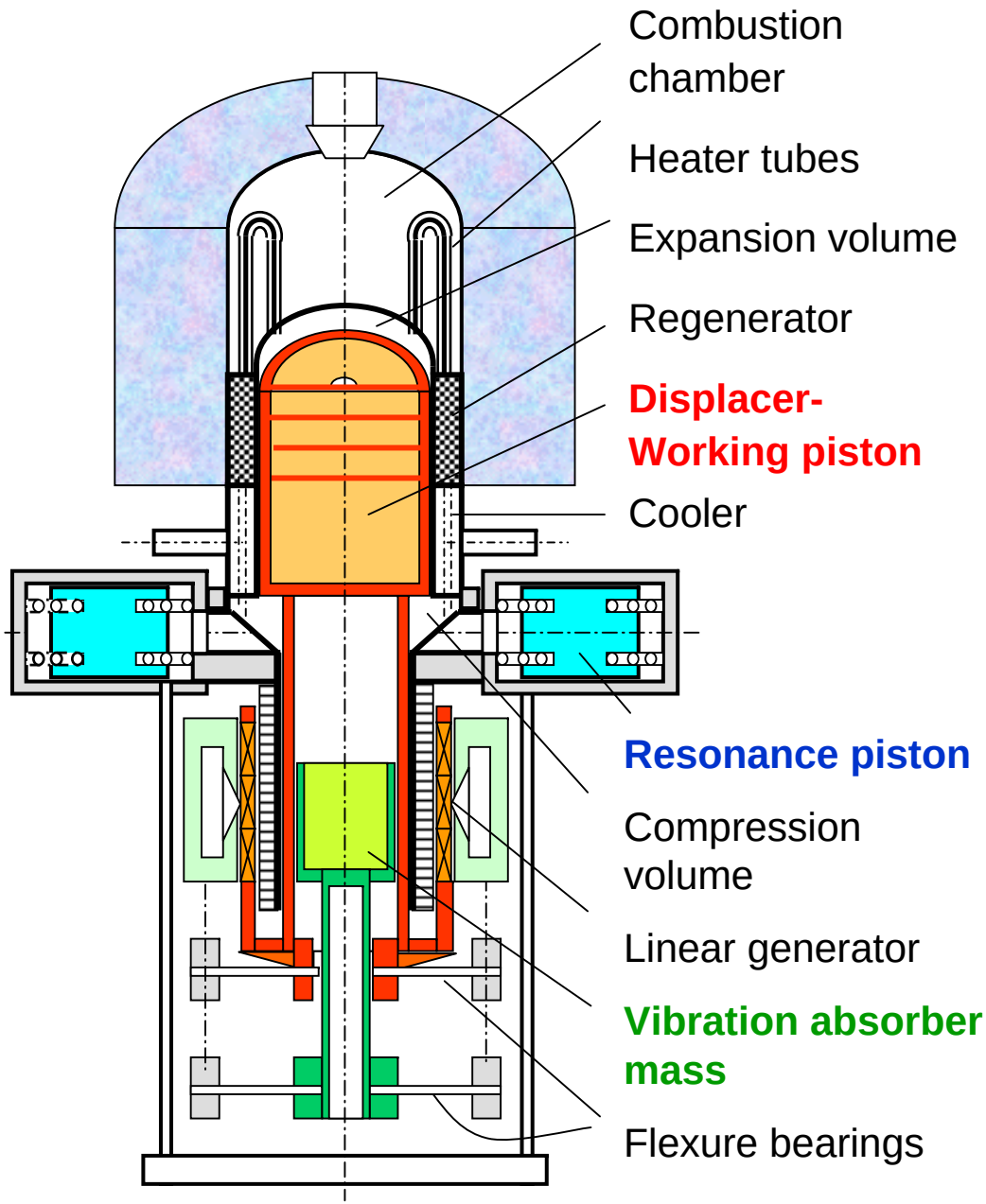
The two pistons must oscillate with a steady phase shift

Conventional Free Piston-Stirling vs. Resonance - Stirling



RESONANCE - STIRLING

MECHANICAL ASSEMBLY

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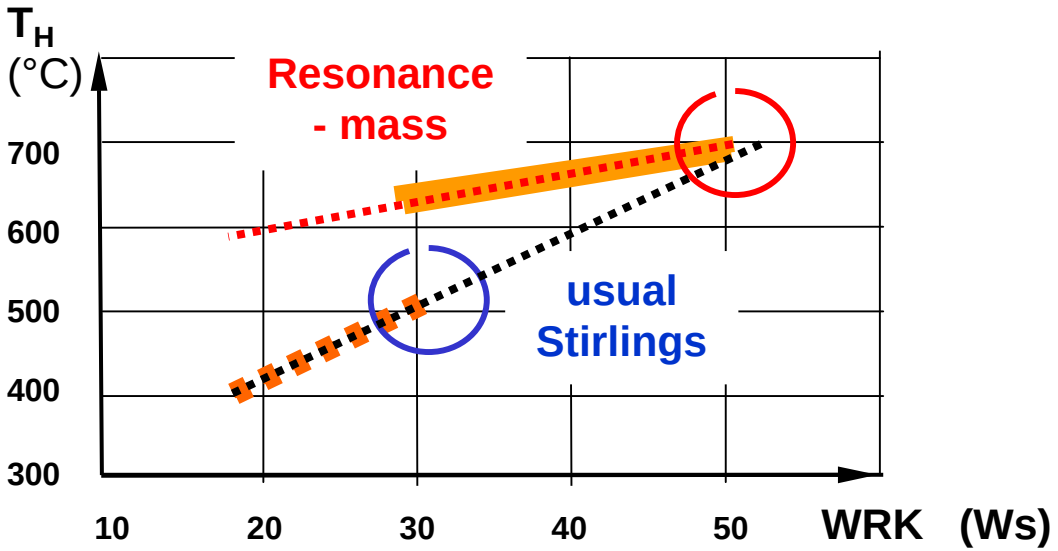
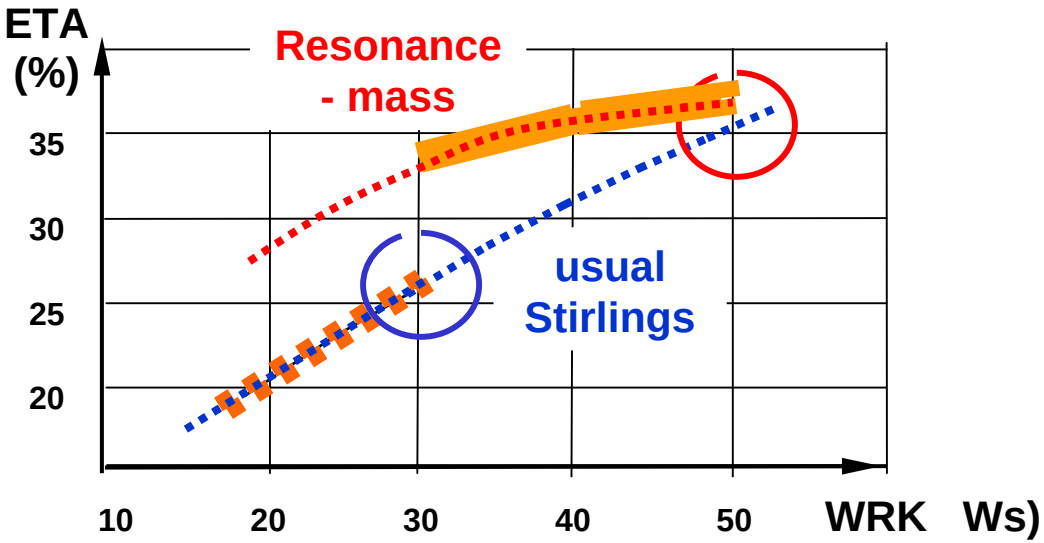
NOMINAL AND PART-LOAD OPERATION

Stable Operating range





PROTOTYPE ENGINE / major experimental data		(expected)
• Available Heat. Energy	Q = 10’000 W	
• Electric Power Output	Nel = 1’800 W	(1500 – 2000)
• electric efficiency	eta = 18 %	(20 – 22 %)
• Total efficiency	etatot (?)	(90 %)
• Pressure ratio	pmax / pmin = 1.32	(1.35 – 1.40)
• Operating frequency	f = 42 Hz	(45 – 50 Hz)

MAJOR ADVANTAGES OF THE RESONANCE ENGINE CONCEPT

Heater tubes may not be overheated

Favourable, flexible part-load operation :

Higher Heater tube temperatures

Higher efficiency (also at part load)

FLOX – Combustion within a large operating range

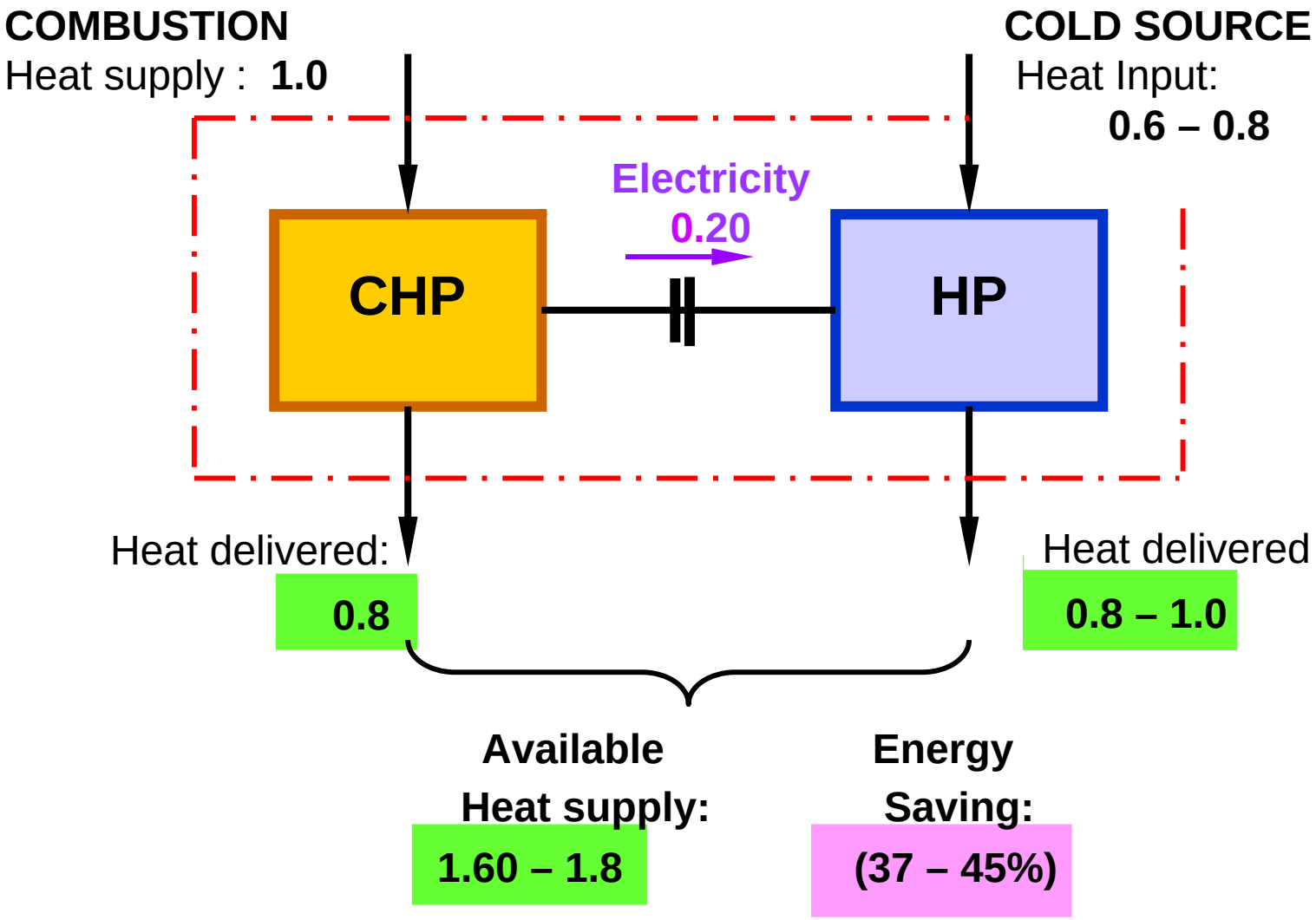
Stable operating conditions,

→ **No need for a complex control system**

High cyclic pressure variations and efficiencies

CHP powering a heat pump (HP)

(VIRTUAL POWER STATION)



ECONOMY

- **Fuel savings ~ 40%**
  (flexible power adjustment to demand)
- **Additional electricity is produced during major demand periods** (in Winter) [220 g CO_2/kWh_{el}]
  (ideally suited for powering heat pumps to demand)
- Affordable cost of the units when produced in series

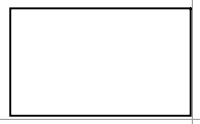
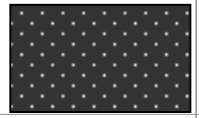
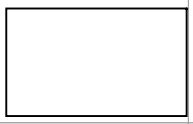
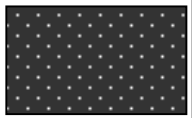
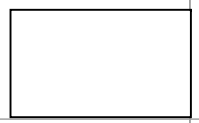
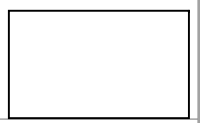
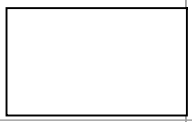
→ Simple Installation (retrofit units)

→ Electric power supply for electric and hybrid cars

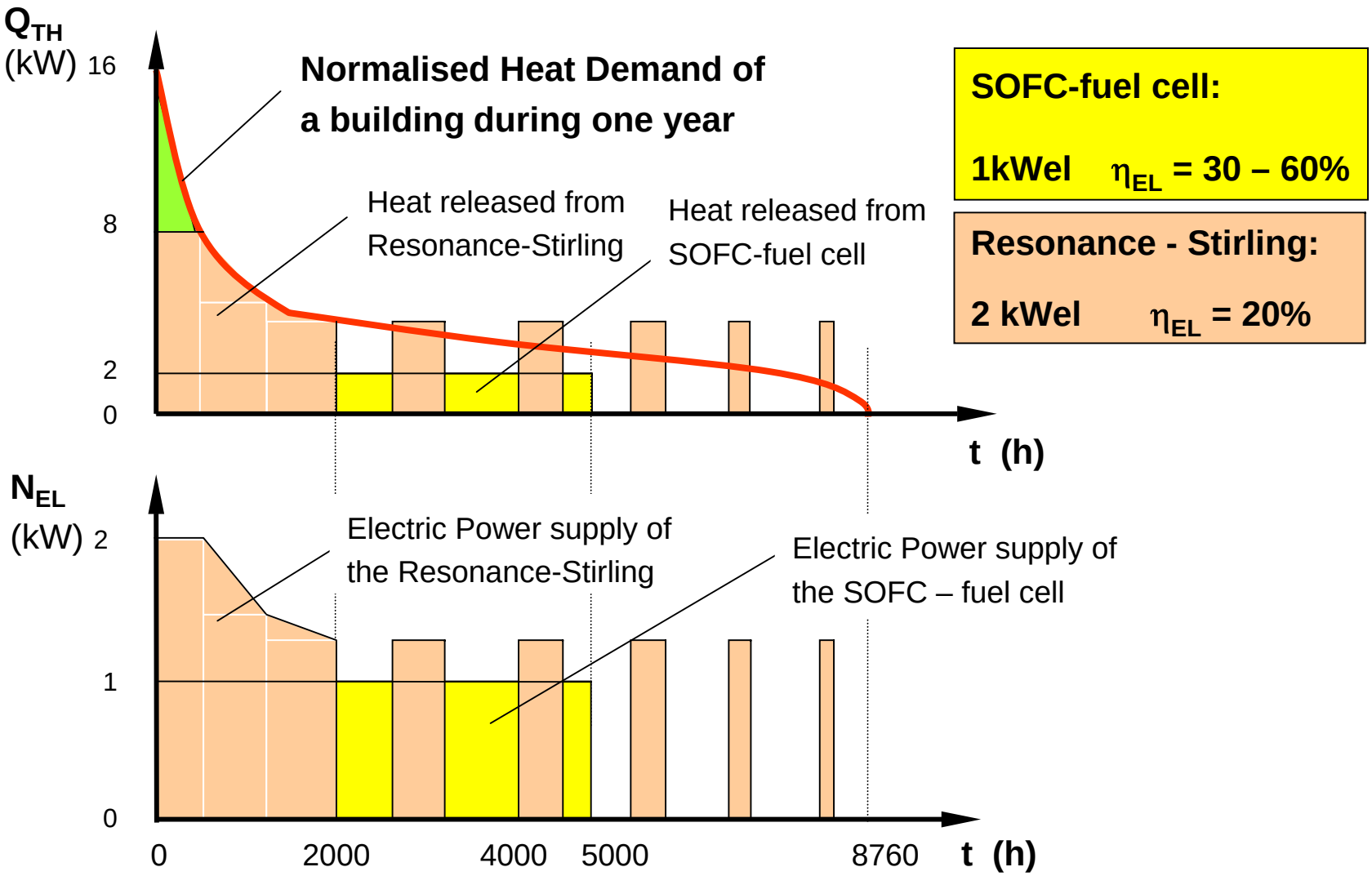
→ Operation with renewable energies (Biomass, Solar)

→ **Reliable operation with minimal maintenance**

COMPARISON OF MAJOR CHP-TECHNOLOGIES

	η_{EL}	Operating lifetime	Maintain. demand	Engine cost	effluents	flexible operation	fuel	Sulfur sensitivity
Diesel-Engine								
Otto - Engine								
Microgen -Stirling								
Resonance **Stirling**								
Rankine cycle								
PEMFC – Fuel-cell								
SOFC – Fuel-cell								

Comparison of heat and power supply of a SOFC-fuel cell with a Resonance – Stirling CHP



SOFC-fuel cell:

1kWel η_{EL} = 30 – 60%

Resonance - Stirling:

2 kWel η_{EL} = 20%

SUMMARY

SIMPLE, RELIABLE ENGINE:
suited for series production

- LONG, MAINTENANCE FREE, FLEXIBLE OPERATION
- SIMPLE START-UP, after pre-heating to more than 500°C
- STABLE OPERATION, with reduced control demand
- HIGH TOTAL AND SUBSTANTIAL ELECTRIC EFFICIENCY
- PART-LOAD OPERATION BY REDUCING HEAT SUPPLY
- HIGH EFFICIENCY AT PART-LOAD CONDITIONS

Additional Information and Further Steps ?

- Adresses: info@stirling.ch
  (e-mail) www.stirling.ch
- PCT - Patent : WO 2011/ 123’961
- US - Patent Appl.: US 2013/ 0031899 A1
- Improvements of the components
- Field-Test-Units → long-term engine testing
- Industrial Manufacture
- commercialisation

} Partners

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THANKS FOR YOUR ATTENTION