Organic Rankine Cycle Engines for Solar Power

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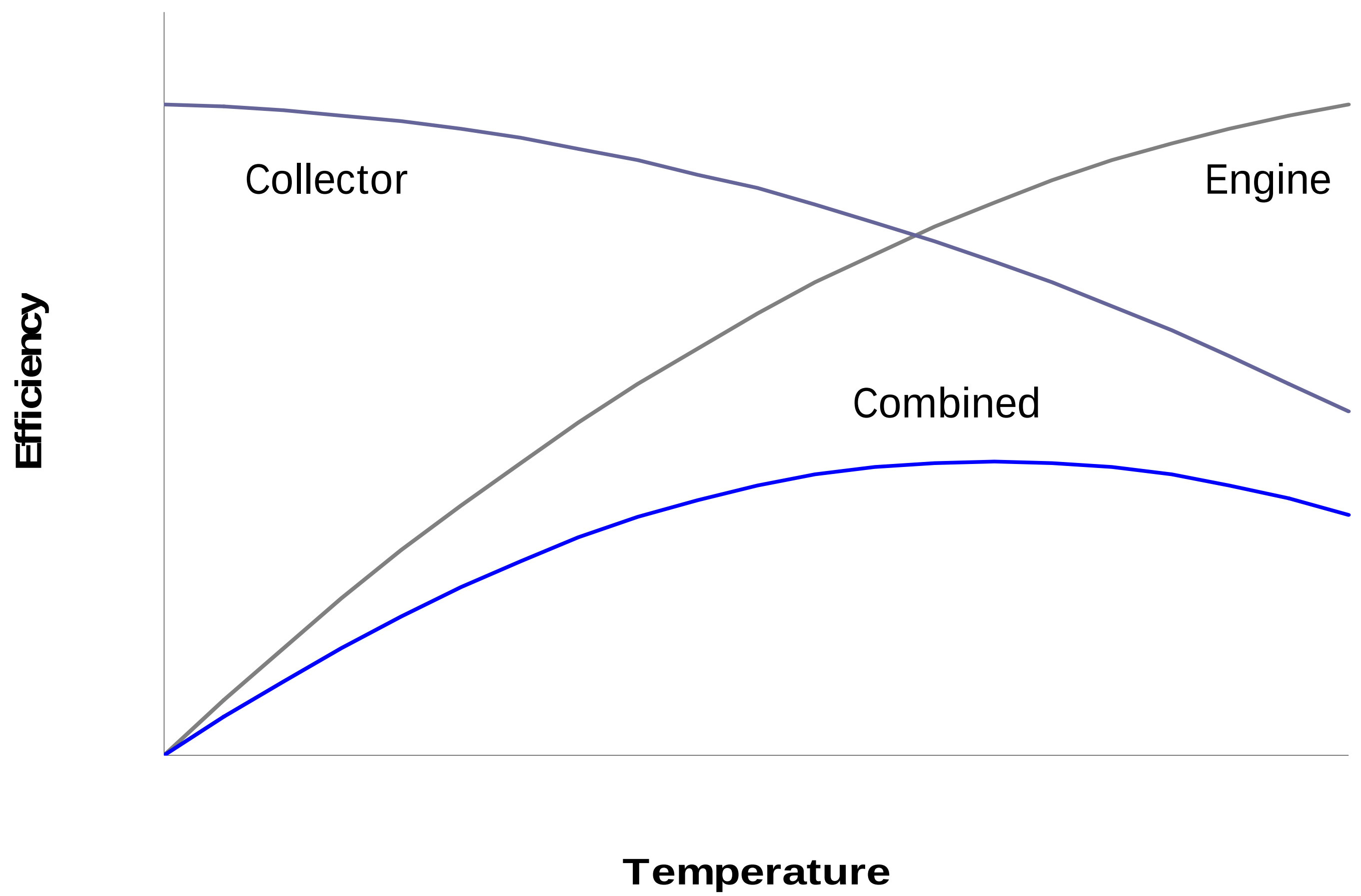
Introduction

- More efficient energy conversion makes solar energy more economical and available
- Combined (overall) efficiency most important

Combined Efficiency



Engine Efficiency

- Maximum and Minimum cycle temperatures determine efficiency
- Carnot efficiency $= \dfrac{T_{max} - T_{min}}{T_{max}}$
- Maximum set by source - Trough collector system
- Minimum set by environment - river, lake, atmosphere
- Target is for real engine to be 50 % of Carnot

Brayton Cycle

- Common gas turbine (jet) engine
- Gas (vapor) cycle
- Aero-derivatives up to 2,700 F

Stirling Cycle

- Most efficient cycle
- Still under development

Rankine Cycle

- Common steam power cycle
- Uses phase change in cycle
  - condense
  - pump up liquid
  - boil
  - expand through turbine
- Steam systems up to 1,200 F & 1,200 psi

Engine Requirements

- Trough collectors improved
- Higher temperatures available to engine
- Engine must be able to utilize higher temperatures

Engine Design Parameters

- Working fluid selection
- Cycle type (subcritical, supercritical, reheat, etc)
- Hardware selection
- System design

Choosing a Fluid

- Desirable properties
  - Low cost
  - Non corrosive
  - Thermally stable
  - Inexpensive
  - High cycle and turbine efficiency
- Steam best choice for high temperature (600 C)
- Organics best choice for lower temperature (100 to 400 C)

Possible Choices

- Refrigerants
- Organics
- Ammonia
- Water
- Toluene (paint thinner) likely candidate
- Mixtures of above
- Fully florinated benzene ring fluids

Toluene Experience

- Ford & Osage City program - 750 F TIT
  - limited operating experience
  - No degradation
- Continental White Cap - 700 F TIT
  - thousands of hours
  - some black ‘gunk’
  - operation not degraded

Summary

- Rankine engines can handle current collector temperatures
- More development needed with working fluids
- Current data base of working fluid history would be extremely valuable (follow on to Hank Curran's work in the early 1980's)