



ProEcoPolyNet

ProEcoPolyNet Best practice Sheet

Annex 42: Stirling Engine”

RTD Project Identification

RTD Project Name: FC+COGEN-SIM:
IEA/ECBCS Annex 42 - The Simulation of
Building-Integrated Fuel Cell and Other
Cogeneration Systems

RTD Contract No.: IEA/ECBCS Annex 42

Programme: Annex 42 operates under the
auspices of the International Energy Agency's
(<http://www.iea.org>) Energy Conservation in
Community Systems (<http://www.ecbcs.org/>)
program

Description of technology

Annex 42 considers modelling of various
cogeneration technologies in the building
environment. This Best Practice Sheet focuses
on Stirling Engines.

The principle of the Stirling engine has been
known for a long time. Unlike reciprocating
internal combustion engines, the heat supply is
from external sources via a heater or heat
exchanger, allowing the use of a wide range of
energy sources including fossil fuels such as oil
or gas, and renewable energy sources like solar
or biomass. Since the combustion process takes
place outside the engine, it is a well-controlled
continuous combustion process, and the
products of combustion do not enter the engine.
The operating gas is compressed at low
temperature in the compression cylinder and
expands at high temperature in the expansion
cylinder. As a result of the continuous
combustion process, two power pulses per
revolution, and fewer moving parts compared to
reciprocating internal combustion engines,
Stirling engines have low wear and long
maintenance free operating periods, and are
quieter and smoother than reciprocating internal
combustion engines.

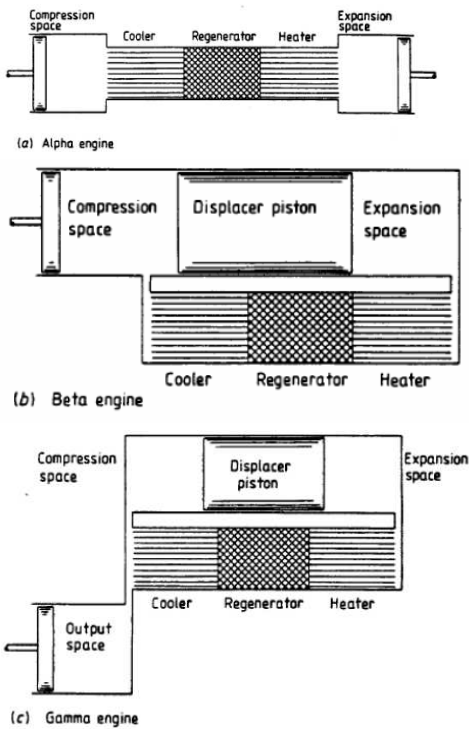
There is an increasing interest in the use of
Stirling engine based cogeneration systems for
residential and commercial cogeneration
because of their prospect for high efficiency,
good performance at partial load, fuel flexibility,
low emission level, low vibration and noise
level¹⁶. A patent for the first Stirling engine was
first granted to Robert Stirling, in 1816. This

technology was used during the 19th century for
various applications including ship propulsion
and ventilation. However, Stirling engine
technology usage was eliminated from the
marketplace early in the 20th century due the
robust and reliable quality of the internal
combustion engines, as well as the cost
reductions derived from the mass production of
internal combustion engines together with the
use of liquid petroleum fuels for transportation
applications. Today, due to several factors
including increased environmental concerns,
cogeneration applications, increased demand for
electricity and the deregulation of the electricity
industry, the market is attracting opportunities
for Stirling engines development

Operating principle

Stirling engines operate on the Stirling cycle,
based on isothermal processes. Stirling cycle
engines have been developed in recent years as
external combustion engines with regeneration,
in which case the cycle resembles the ideal
Carnot cycle.

Stirling engines are classified according to their
arrangement: the Alpha, Beta and the Gamma
arrangements as shown in Figure 26. The Alpha
configurations have two pistons in separate
cylinders connected in series by a regenerator,
heater and cooler. Both the Beta and the
Gamma configurations use the displacement
piston arrangement, but the Beta arrangement
has the piston and the displacer in the same
cylinder while the Gamma arrangement uses
different cylinders. Stirling engine drive methods
are based on kinematic drive and free piston
drive. Kinematic drives utilize conventional
mechanical elements like the cranks, connecting
rods and flywheels in series that move in a
prescribed manner. On the other hand, the free
piston drives move the reciprocating elements
using the pressure variations produced by the
working gas, with the work being harnessed by
a linear alternator.



Technical characteristics of installation

- ▶ *Type: Stirling engine*
- ▶ *Electrical output capacity (kW): 2 – 9.5*
- ▶ *Thermal output capacity (kW): 8-26*
- ▶ *Electrical efficiency (%): 40 (can be up to 50 in future)*
- ▶ *Total efficiency (%): 65-85 (up to 92)*
- ▶ *Power to heat ratio: 1.2 – 1.7*

Stirling engines also have good capability to operate under part-load conditions.

Stirling engines operate smoothly, resulting in lower vibration and noise level.

Location and use

- ▶ *Private Buildings*
- ▶ *Residential Buildings*
- ▶ *Commercial Buildings*
- ▶ *Public Buildings*
- ▶ *Others*

Capital investment and maintenance costs

- ▶ *Capital investment*

Cost of unit (2001€) 8200

Installation cost (€) 2050

Total Cost (2001€) 10,200

Presently, the investment cost for the unit is still about twice as high as an internal combustion engine CHP unit of the same capacity.

▶ Maintenance

Service intervals are from 5,000 to 8,000 hours, which are long compared with Otto gas engines of the same range. This considerably reduces the operating costs. Due to the tight sealing of the casing, the free piston Stirling engines are expected to eliminate mechanical contact, friction and wear, therefore eliminating mechanical maintenance during an operating lifetime of about ten years.

- ▶ *Specific maintenance costs (€/kWh): 0.010*

State of Development/Market implementation

- ▶ *Prototype*
- ▶ *Field tested*
- ▶ *Serial production*
- ▶ *Full market implementation*

CO2 and primary energy savings

Fuel (kg/kWh)

NOx, (gm/bhph): 0.08- 0.12

CO, (gm/bhph): 0.04- 0.06

Benefits and obstacles

With the exception of micro-turbine systems, these technologies are suitable for single- and multi- family residential applications (1 - 10kW). From the technological perspective, fuel cell and Stirling engine cogeneration systems seem promising for residential applications; however, before these systems can see wide spread acceptance, their affordability and reliability must be improved significantly.

Currently, well-proven and robust systems available for residential as well as small-scale commercial cogeneration applications at reasonable cost are based on reciprocating internal combustion engines.

Contact and further information

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