Solid Energy Technologies

Waste and Biomass derived energy using

Direct Solid Fuel Recuperated Gas Turbine Engines

Contact

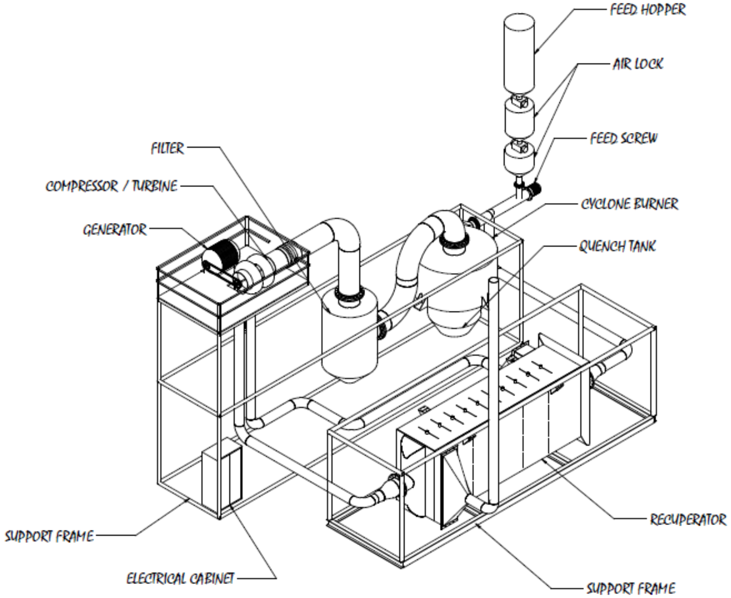
Bevan Dooley

Solid Energy Technologies

Ph +61 404 467 024

bdooley@solidenergytech.com

www.solidenergytech.com



Key Points

- 0.25, 0.5, 1 & 2MW units
- Ash removal by slagging cyclone combustor and high temperature filter
- Replaceable turbine and wearing sections (Manufactured from Inconel 713C superalloy)
- Burn all grades of coal
- Burn refuse derived fuels (RDF & PEF)
- Burn Biomass meeting specific ash slagging criteria

Cost comparison

Cost of generating power using diesel	-	$150/MW.hour	*
Cost of generating power using Coal	**-**	**$25/MW.hour**	**
Cost of generating power using Refuse Derived Fuel		**$10/MW hour**	***

* Based on diesel at US$ 0.50/litre using reciprocating engines at 35% efficiency (75% load)

** Based on a coal price of $50/ton using DSFR turbines at 30% efficiency

*** Based on RDF being delivered to recovery facility at no cost and $20/ton allowance for densification

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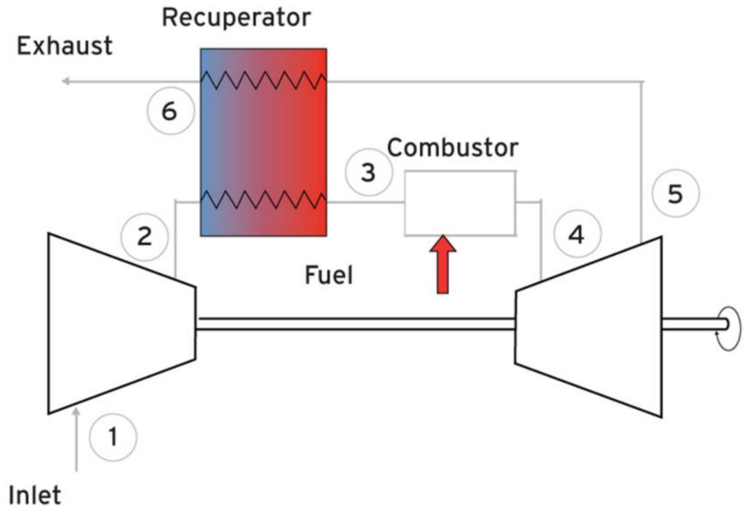
Principle of Operation

The SET solid fuelling gas turbine works on exactly the same core principle as a regular recuperated turbine engine. The technical advantage lies in the combustor and hot end turbine design

1. Air is pulled into the engine compressor
2. Air is compressed to 6 Bar and flows into the recuperator
3. The air is preheated using spent exhaust gases to recover energy and flow into the combustion chamber
4. Fuel is added to the combustion chamber heating the air
5. The air expands through the turbine providing
    1. Shaft Power needed to drive compressor
    2. Shaft power to the load
6. Spent exhaust gases then flow through the recuperator and out to emission reduction or atmosphere



Principle of Operation

The BTOLA DSFR system operates as below, differences are highlighted in red

1. Air is pulled into the engine compressor
2. Air is compressed to 6 Bar and flows into the recuperator preheating it to around 400 C.
3. Hot Compressed air is diverted to a large specially designed external cyclonic combustion chamber
4. Solid fuel is metered into the combustion chamber via the incoming hot compressed air stream
5. The solid fuel is thrown by centripetal acceleration to the outer walls of the combustion chamber where it adheres to a sticky molten ash layer and being constantly washed with fresh incoming air and burns out within seconds. The molten ash flows from the combustion chamber into the ash quench tank
6. The superheated (1400 ^{o}C) compressed combustion gases are mixed with excess air and cools rapidly to 1000 ^{o}C and flows into the turbine.
7. The air expands through the turbine providing
    1. Shaft Power needed to drive compressor
    2. Shaft power to the load
8. Spent exhaust gases then flow through the recuperator and out to emission reduction or atmosphere

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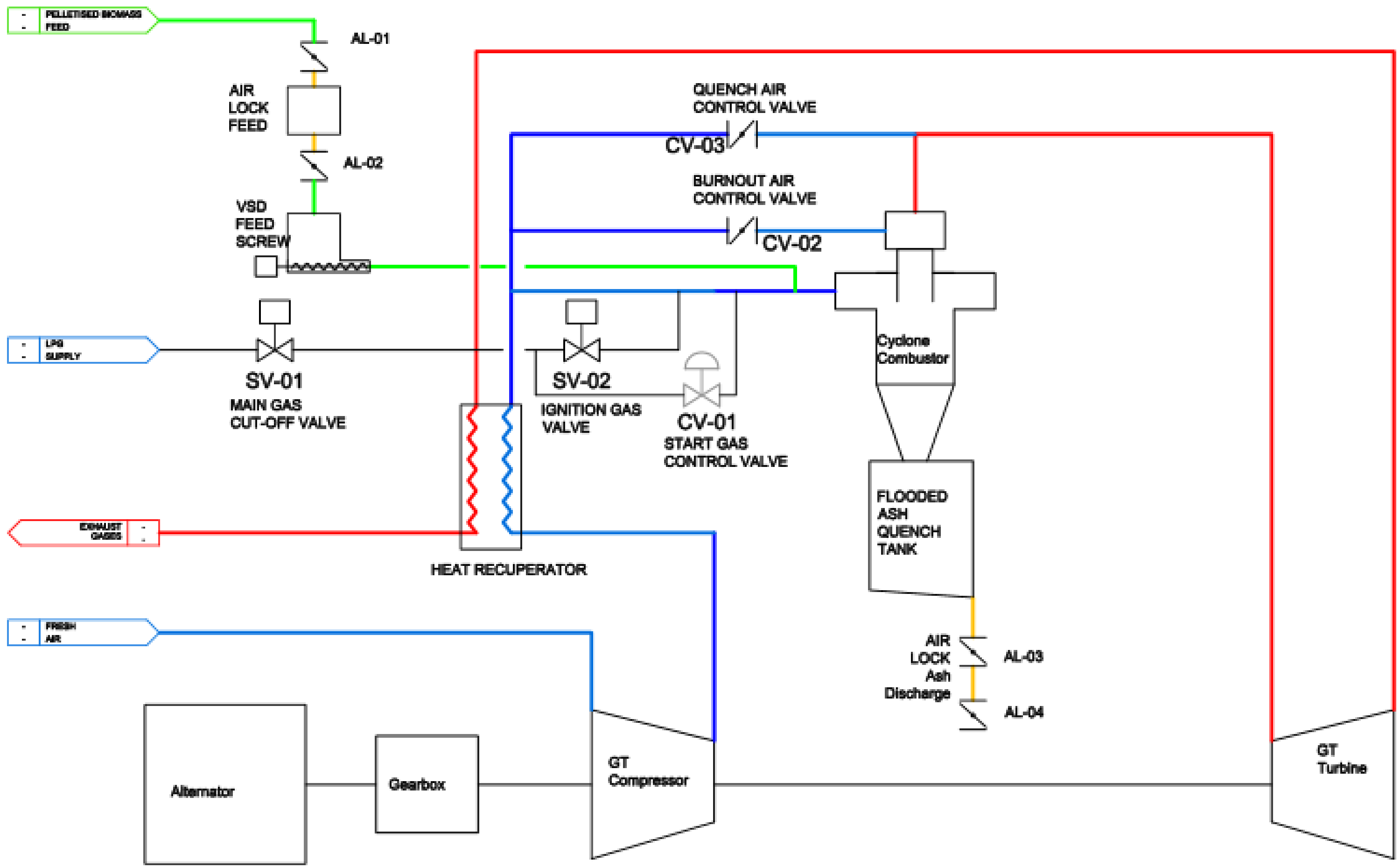
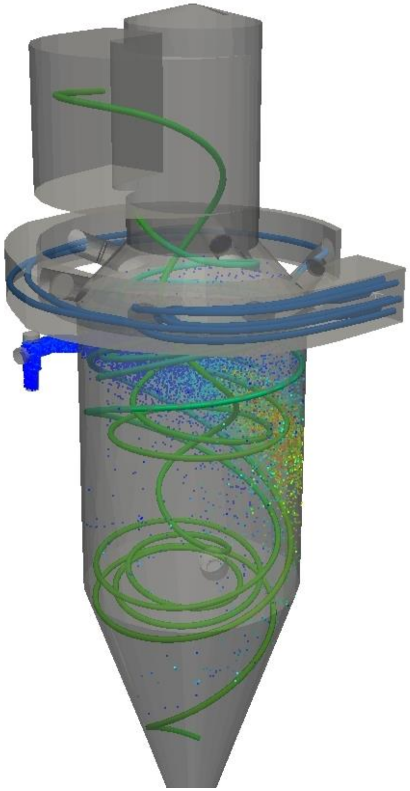


Emission Controls

The Cyclone Combustor

- High temperature incineration conditions between 1200 - 1400 ^{o}C allows
  - The combustion of materials containing noxious chemicals
  - Higher ash fuel materials as the ash is separated out in the combustor
  - Vitrifies the Ash leaving a glass sand in the quench tank which is removed by simple sluicing
- Large particle range 1mm – 15mm
- Minimal fuel preparation energy required
- Ultra Low Emissions



Emission Controls

Emissions are controlled by adhering to the European Commission – Best available techniques for waste incineration August 2006 which include:

- High temperature incineration conditions between 1200 - 1400 ^{o}C
- A residence time above 2 seconds
- Staged combustion system providing for the following conditions
    - Reduction zone
    - Oxidation – burnout zone
    - Quench Zone to reduce NOx formation
- Continuous combustion chamber temperature monitoring
- Continuous Oxygen monitoring
- Tail end baghouse or wet scrubber available upon request.

Measured emissions from RDF

Compound	Emission Concentration (mg/Nm3)	Emission Rate (mg/s)
Particulates (TSP)	0.77	7.392
Particulates (PM10)	0.99	9.504
Sulphur Dioxide	< 2.9	< 27.5
Oxides of Nitrogen N0x	92	840
Carbon Monoxide (CO)	24	230.4
Volatile Organic Compounds (VOC's)	< 0.9	< 8.5

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Quick Replacement Turbine Parts

Inconel 713C nozzle Rings

Supplied in rough casting for final machining

by the Solid Energy Technologies team

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Supplied in rough casting for final machining

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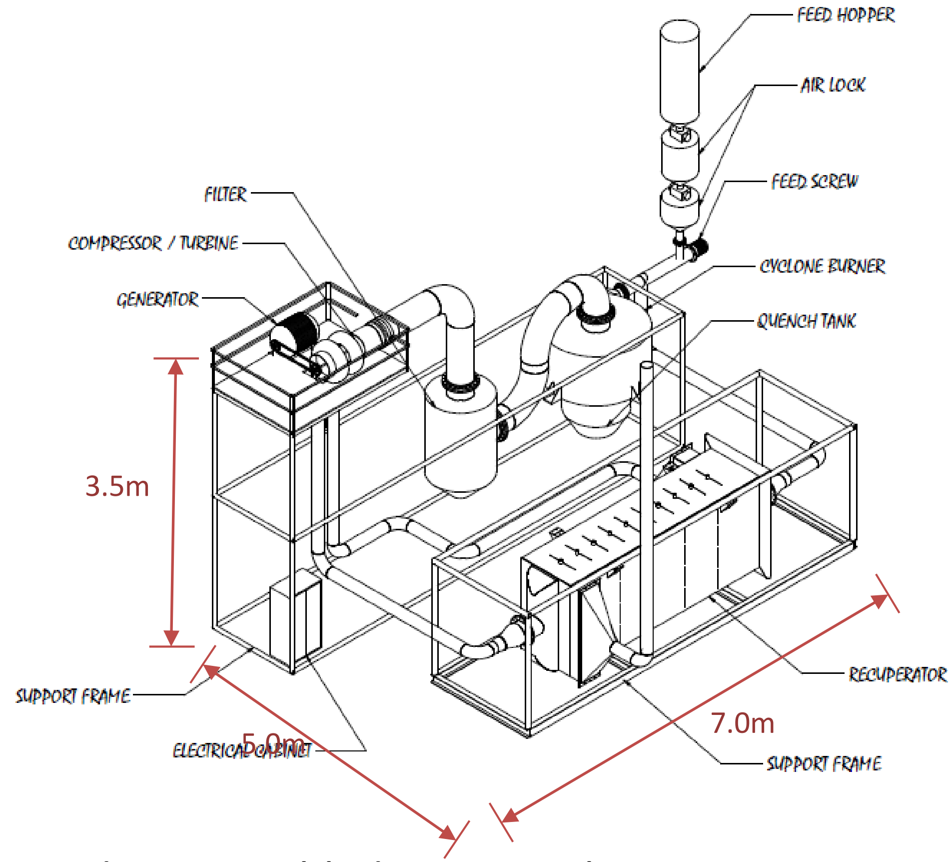
Footprint of Unit

The 2MW unit is shipped as

- Recuperator skid
  - 6m x 2.4 x 2m high
- Combustor skid
  - 6m x 2.4 x 2m high
- Turbine skid
  - 3 x 2.4 x 1.5 high
- Loose items
  - Air lock system



The skids are pre-wired and designed to assembled on site in hours

MSW to Energy Process

Simple Municipal Solid Waste processing into Refuse Derived Fuel

1. Bag opening – to prepare the MSW for segregation
2. Sifting to remove small particles (batteries, broken glass, sand and dirt)
3. Magnetic separation – recover valuable scrap steel
4. Belt Picking – lift the poor to a better standard of living by providing clean and safe working conditions with assured income.
5. Optical Near Infrared Sorting to reject PTF, Teflon, Metals etc.
6. Air Separation to take out the combustibles
7. Densification to allow high density storage and feeding of the plant
8. Conversion to energy in DSFR units.
9. Vitreous sand is used as road-base or concrete aggregate

Technology Comparison

Technology	Capital Cost	Operating Cost	Efficiency	Water Required	Skill Level Required
DSFR - Direct Solid Fuelling Gas Turbine	Low	Low	Good ~ 30%	Very Low	Low
Conventional Boiler Steam Turbine	Medium to High	Medium to High	OK ~ 25-30% depending on scale	High make-up feedwater & cooling	Medium
Plasma Boiler Steam Turbine	Very high	Very High	Low due to plasma torch consumption requires supplementary fuel	High make-up feedwater & cooling	Very High
Gasification – Gas Turbine	High	High	Low ~ 17% due to energy losses	Medium for gas cooling	Very High

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Contact

Bevan Dooley
(Managing Director)
Solid Energy Technologies

13 Apprentice Drive
Berkeley Vale NSW 2261

Ph +61 404 467 024
email: bdooley@solidenergytech.com
Web www.solidenergytech.com