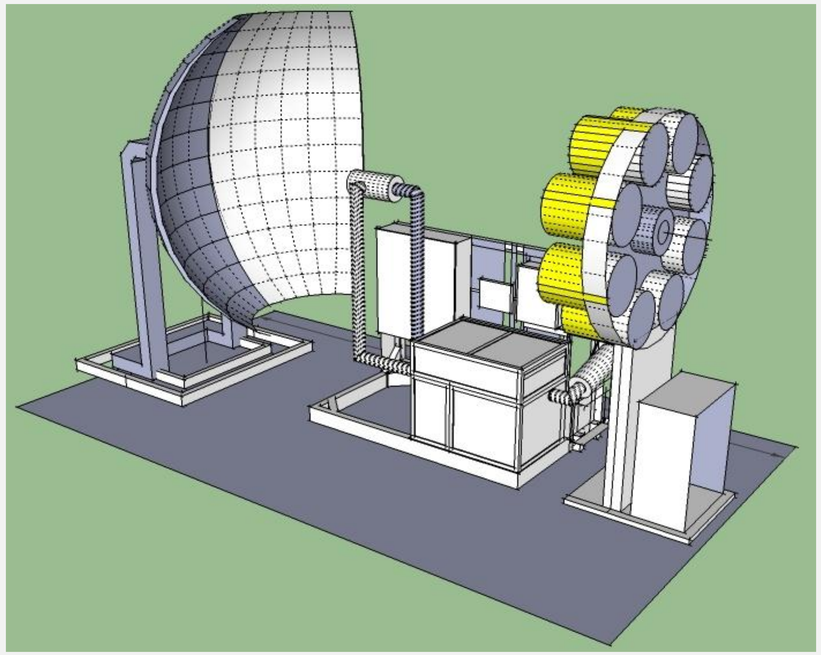
Modeling and Analysis of a Hybrid Solar-Dish Brayton Engine



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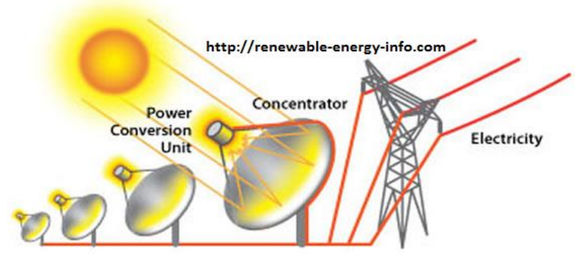
Introduction

The negative environmental impacts of fossil-fuel electricity production emphasize on using more renewable energy sources in power generation. Electricity production using **solar energy** is well known as one of the promising solutions for ever-growing problems of global warming and limited supply of fossil fuels.

It is well known that dish-engine systems demonstrate the highest solar-to-electric efficiencies, compared to other solar technologies[1,2]. High efficiency, hybridization potential, modularity and low cost potential make them excellent candidates for small-scale decentralized power generation[1, 2].A number of units can be grouped together to form a dish-engine farm and produces the desired electrical output[1].



Advantages

- Relatively high efficiency
- Modularity
- Relatively low land requirement
- Hybridization potential
- Relatively low cost potential
- Low environmental impacts

Applications

- **Decentralized power and Heat/Chill**
  - In stand alone system for a house or for water pumping
  - with multiple units for the village-power market
- **Dish-Engine farm**

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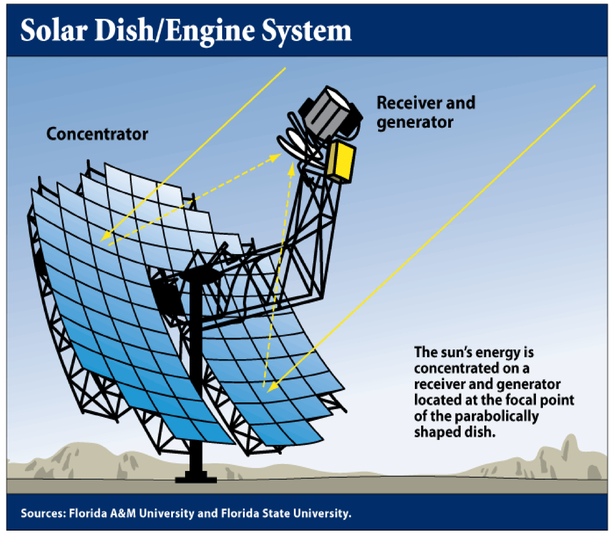
Background & Objectives

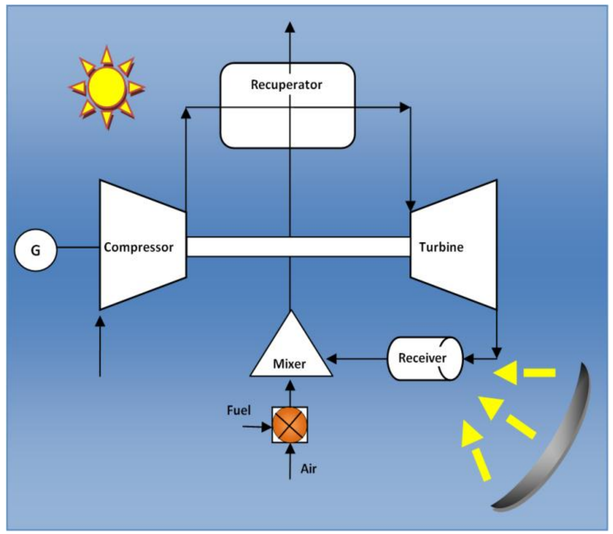
In most contemporary dish-engine systems, Stirling engines[3] have been used as the power conversion unit; however, small-scale recuperated gas turbines would appear to have considerable potential to be used in solar-fossil fuel hybrid dish systems. The gas turbine integrated with a solar receiver is known as a dish-Brayton.

They show a number of advantages when compared with Stirling engine systems, chief amongst them a significant reduction in O&M costs and simplified hybridization schemes. Recent developments in the fields of high-temperature recuperators will allow gas turbine systems to compete directly with Stirling engines in terms of efficiency.



Objectives

- The hybrid solar gas turbine can be configured in several different fashions, with the key difference being the relative positions of the solar receiver and combustor as well as the operation mode of the combustor.
- The main objective of this thesis is to study the performance of various configurations; This goal is achieved by modeling and simulation of different possible configurations.



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Report

Report Description

- BACKGROUND
- OBJECTIVES & SCOPE OF THE PROJECT
- SYSTEM DESCRIPTION
  - a •GAS TURBINE SPECIFICATIONS
  - b •TEST RESULT OVERVIEW
  - c •SOLAR HYBRID SYSTEM DESCRIPTION
  - d •LAYOUT DECSRIPTION
- MODELING & RESULTS
  - a •MODEL DESCRIPTION
  - b •TRANSIENT MODEL RESULTS
  - c •STEADY-STATE MODEL RESULTS
  - d •MODEL ANALYSIS
- CONCLUSION AND FUTURE WORKS

Conclusions

Small-scale recuperated gas turbines with a highly efficient recuperators are shown to have considerable potential to be used in solar/fossil-fuel hybrid dish systems. (18-20% average electrical efficiency through one year operation)

The integration of a solar dish/receiver into a micro gas turbine based CHP plant can reduce the yearly fuel consumption by 15-40% depending on solar irradiation and results in reductions of CO2 emissions as well as leading to lower daily operating costs.

The hybrid nature of the Dish-Brayton system guarantees availability of the engine to meet the electricity demand whenever it occurs, allowing the system to supply dispatchable power.

References:

[1] “Solar dish engine”, Solarpaces.org, http://www.solarpaces.org/CSP_Technology/docs/solar_dish.pdf

[2] H. Muller-Steinhagen, F. Trieb, “Concentrating Solar Power”: A Review of the Technology, Köln, 2004

[3] R. Pitz-Paal, J. Dersch, B. Milow, “European Concentrated Solar Thermal Road-Mapping”, 2004

[4] A. Malmquist, (2008), Biogas för El och Uppvärmning, Compower AB, Sweden, http://www.compower.se/