# CALIFORNIA STATE SCIENCE FAIR
# 2006 PROJECT SUMMARY

**Name(s)**
Matthew S. Shepherd

**Project Number**
**S0813**

**Project Title**
## Optimization of Biomass Conversion: Pilot Study Evaluation of the Use of Low-Grade Steam to Reform Methane

**Abstract**

**Objectives/Goals**
My project assessed the opportunity to reduce greenhouse gas emissions by producing transport-grade hydrogen fuel through low-grade steam reformation of methane off-gas produced during anaerobic digestion of municipal wastewater. In the common industrial process for hydrogen production, carbon-hydrogen bonds of methane are broken in the presence of steam, generating hydrogen gas. I postulated that if steam reformation were an equilibrium-driven replacement reaction, then it would go to completion in the presence of excess steam according to Le Chatelier's principle.

**Methods/Materials**
I constructed a continuous process reaction chamber using ice chests, PVC and galvanized steel piping, metal mesh screens, crushed ice, and a home steam cleaner. I also built a frame and cone to hold the catalyst. I used methane, hydrogen, a propane torch, aluminum oxide, Drano, a home pressure cooker, and pH paper.

**Results**
Both continuous-process investigations at atmospheric pressure and pressurized batch pilot studies demonstrated that Le Chatelier's principle does not apply to the reaction since low-grade steam, even in excess, did not produce the intermediate carbocation necessary for hydrogen generation. Additional experimentation was conducted in the presence of aluminum oxide to see if a catalyzed reaction would proceed without high pressure or superheated steam.

**Conclusions/Discussion**
Experimental investigations with pure methane and steam demonstrated that the reaction was so endothermic that the reaction was not reversible and hence not subject to the Le Chatelier principle because low temperature steam did not successfully reform methane. Additional experimentation conducted in the presence of aluminum-oxide in a pressure cooker to see if it could catalyze the reaction and get it to proceed at relatively low temperatures was unsuccessful.

**Summary Statement**
This pilot study was designed to evaluate the efficacy of biomass conversion using low-grade steam to reform methane.

**Help Received**
Ted Cruz of AirGas supplied lecture bottles of methane and hydrogen for experimentation. My parents critiqued my board layout and reviewed my batch and process experimental designs to reduce the likelihood of having a boiler explosion.