FREE-PISTON LINEAR GENERATOR

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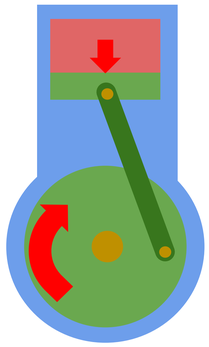
Project Goals

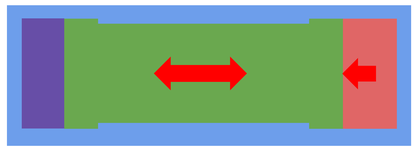
Long-term: Develop a high-efficiency linear generator powered by hydrogen.

This year: Design and build a compressed air powered FPLG to develop hardware and control algorithms.

Why Design a Linear Engine?

- The linear design has less friction than rotating engines by turning linear motion directly into electricity.
- They are applicable as a range extender for hybrid vehicles.





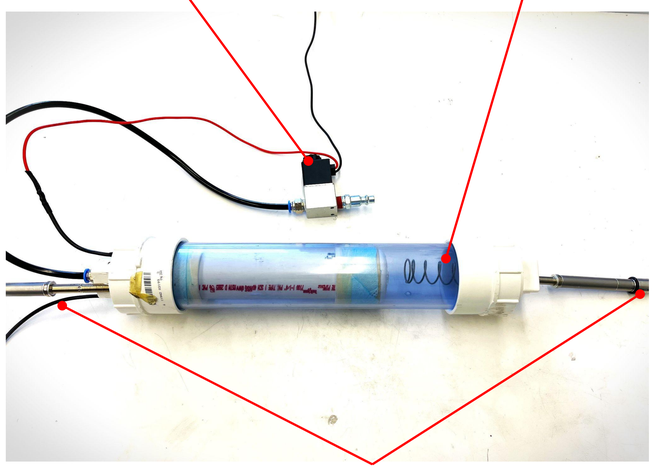
Above: A free-piston engine schematic.
Left: A 'standard' rotating engine schematic.

Frictional losses occur when converting linear motion to rotational motion. The free-piston concept bypasses this and leads to higher theoretical efficiency.

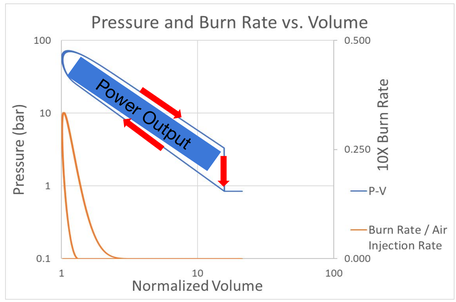
Proof of Concept (Skunkworks)

Solenoid Valve Air Injector
Supplies compressed air triggered by a switch when the piston nears top dead center. Compressed air is sourced from an air compressor.

Compression Spring
Supports the air spring in returning the piston back to top dead center



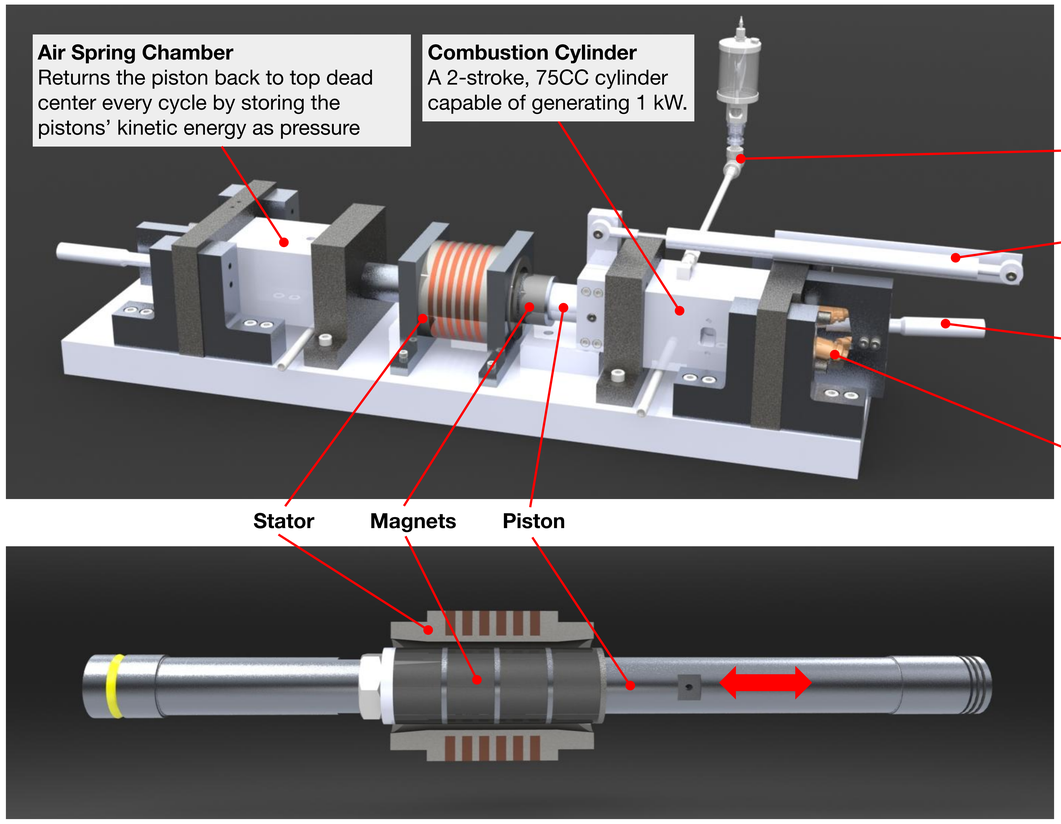
Pressure Sensors
Measure the pressure developed in the combustion and air spring chambers.



Modeling and Analysis

- We created a computational model of the engine to determine how big it needed to be to generate 1 kW.
- Power output was determined by plotting cylinder pressure vs. volume during a cycle.
- The engine can generate 1 kW with a 40 mm bore and a 60 mm stroke.

Assembly Overview



Oil Delivery System
Braided lines deliver oil to the cylinders, keeping friction and wear low.

Position Sensor
Measures real-time piston position to inform control logic, initiating air injection events.

Pressure Sensor
Continuously measures the pressure in the combustion chamber and helps calculate the work done.

Air Injectors
GDI fuel injectors for supplying compressed air to the combustion chamber, powered by Syvecs Injection Driver.

Generator

- Magnets on the piston pass through a steel stator wrapped with copper coils.
- Relative motion induces a voltage in the coils, generating electricity. This is a 3-phase, 2 pole generator.
- The power produced is dissipated through variable resistors.

Piston

- The piston is rigid and spans between the combustion cylinder and the air spring.
- Piston rings seal combustion gasses and a PTFE seal in the air spring chamber provides high sealing efficiency while keeping friction low.

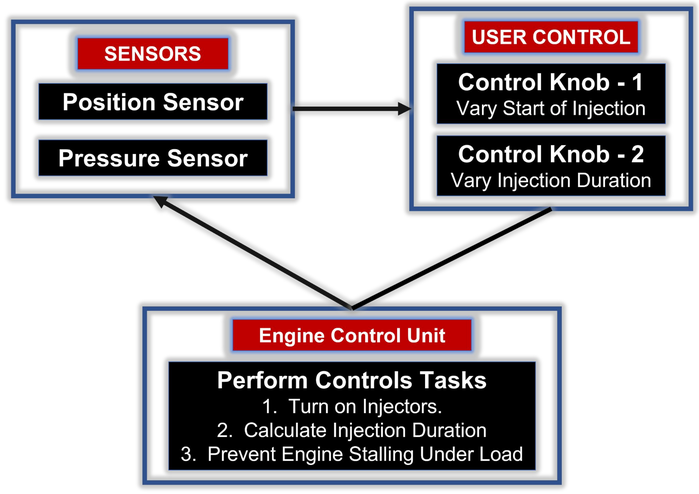
Project Requirements

- Two-stroke linear engine
- 1 kW power output
- 150 bar maximum operating pressure with 5x safety factor

Future Work

1. Complete manufacturing and finish engine assembly.
2. Prepare engine test plan and get it approved.
3. Design and build a safety cage to contain parts in the event of failure
4. Perform engine testing with compressed air.
5. Implement combustion to fulfill the project goal.

Engine Control Flow



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