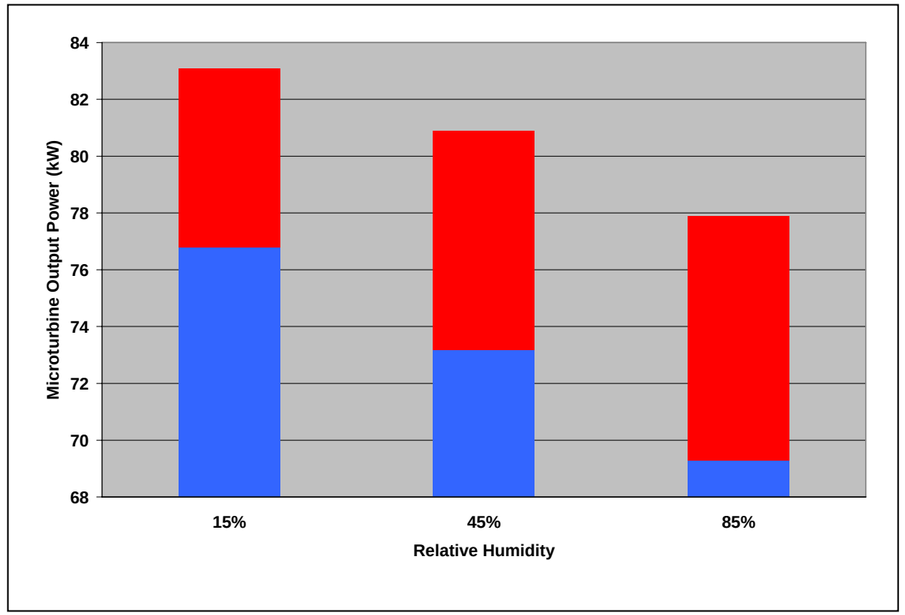

Power Augmentation vs Ambient Relative Humidity
Evaporative Cooling; Supercharged with Evaporative Cooling

Your Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.
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COMMUNITY ENERGY SYSTEMS

CLEAN ENERGY TECHNOLOGIES

INLET AIR SUPERCHARGING

The Issue

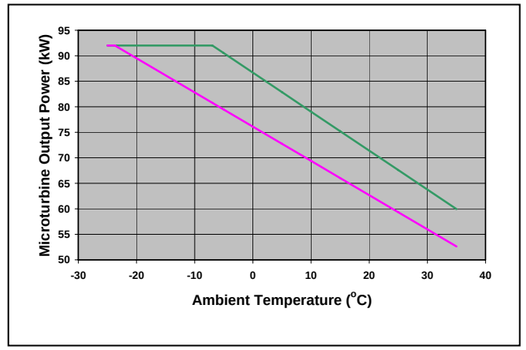
1) Gas turbine power output decreases as ambient air temperature increases and/or ambient pressure decreases, essentially since air density is lower.

The gas turbine, as a capital asset, is fully exploited only when the air temperature is very low and ambient pressure is high. At all other temperatures/pressures, the opportunity to maximize return on investment is missed.

2) Value of power generally increases as air temperature increases (in the summer), since demand for power generally increases.

So, at those times when the potential benefit from the investment is the greatest, the capability of the asset is the least.

3) Therefore, additional investment may be justified to recover lost capacity, and this additional investment may be less, in terms of $/recovered kW, than the investment in the gas turbine itself.



Microturbine Power Production vs Ambient
Temperature Sea Level; Calgary (1084 m above SL)

Potential Solutions

1) Inlet air-cooling is the most common approach to recovering capacity that would be lost due to high ambient temperature. There are three methods:

- Evaporative cooling employing a wetted media;
- Inlet air fogging – injecting fine water droplets into the inlet air stream;
- Mechanical or absorption refrigeration.

2) An approach that was been successfully used on a few industrial gas turbines, such as the Westinghouse B10 rated at 40 MW in the 1960's, is Inlet Air Supercharging.

What is Supercharging?

1) A gas turbine is supercharged if the inlet pressure exceeds the exhaust pressure. This will tend to increase power output in two ways:

- Increased gas turbine compressor inlet air density;
- Increased gas expansion across gas turbine power turbine.

Canada

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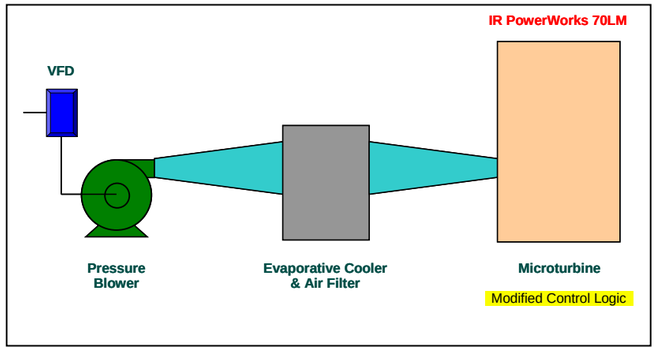
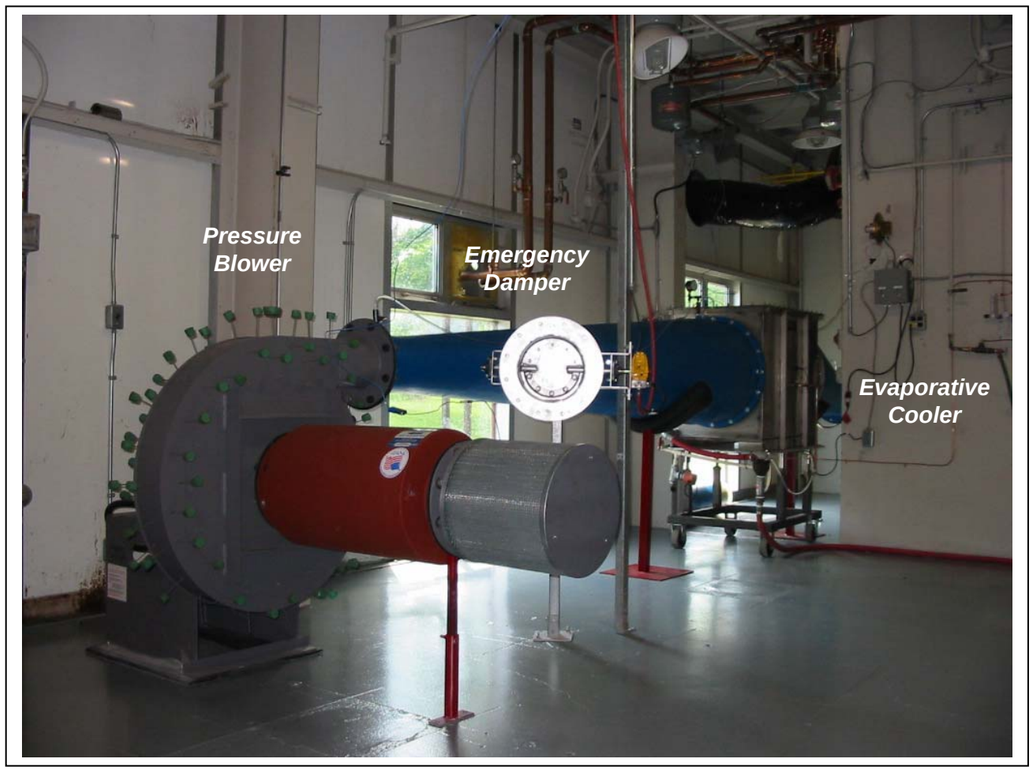
2) Though Inlet Air Supercharging is a proven technique, the early attempts to apply it to stationary engines were uneconomical due primarily to the prevailing “spark spread”. Also controlling the inlet fan proved difficult.

3) The company Enhanced Turbine Output LLC (ETO) has recently patented an improved technique for supercharging of stationary gas turbines which they call PowerCool.

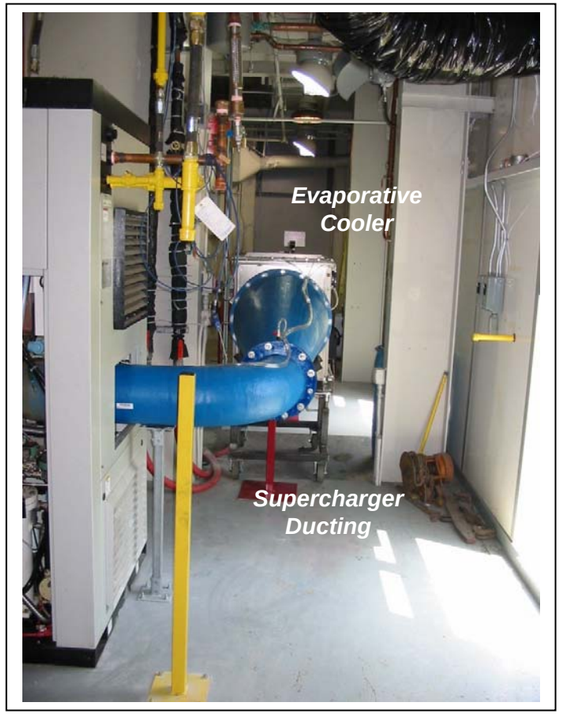
4) CANMET is investigating this gas turbine supercharging concept under agreement with ETO.



CANMET Simplified Test Set-up



CANMET Laboratory Installation



CANMET Laboratory Installation
Microturbine
IR PowerWorks 70LM

Economic Analysis

- Using hour by hour power data an economic analysis was carried out using 2005 Toronto weather and power price data
- Complete results will be published at ASME TurboExpo 2006 in Barcelona in May 2006
- Results indicate that although supercharging a single 70 kW might not be cost effective, economies of scale result in the concept being economic in Ontario with multiples of 4 x 70 kW turbines or a 250 kW turbine

Investigation Plan Going Forward

Stage 1 – Laboratory Testing

Completed

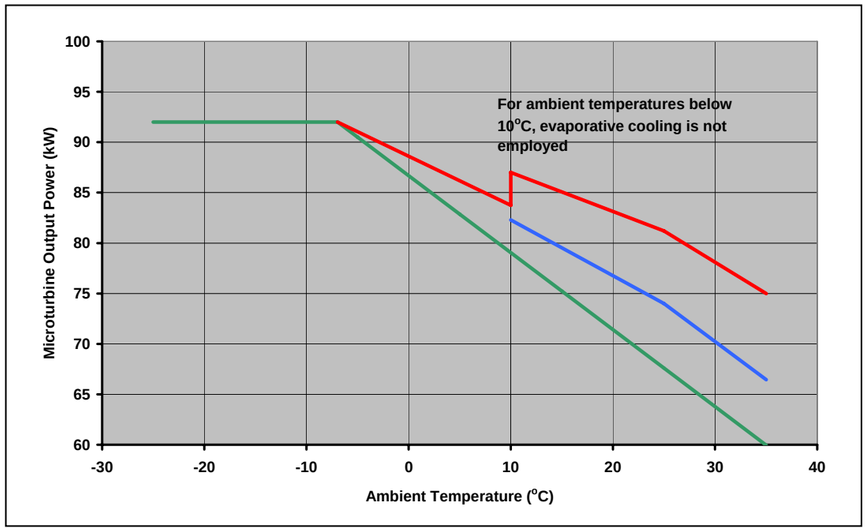
Stage 2 – Field Trial

Relocate and reinstall the supercharging system to a field installed PowerWorks 70LM and monitor the system operation over the long-term.

CANMET is interested in working with partners (including those in the US) to field trial the concept.

Stage 3 – Large Machine

Investigate technical feasibility and economic potential to provide a supercharging/inter-cooled system larger (MW) gas turbine.



Microturbine Output Power vs Ambient Temperature
Inlet Air: Normally Aspirated; Cooled only; Supercharged and Cooled